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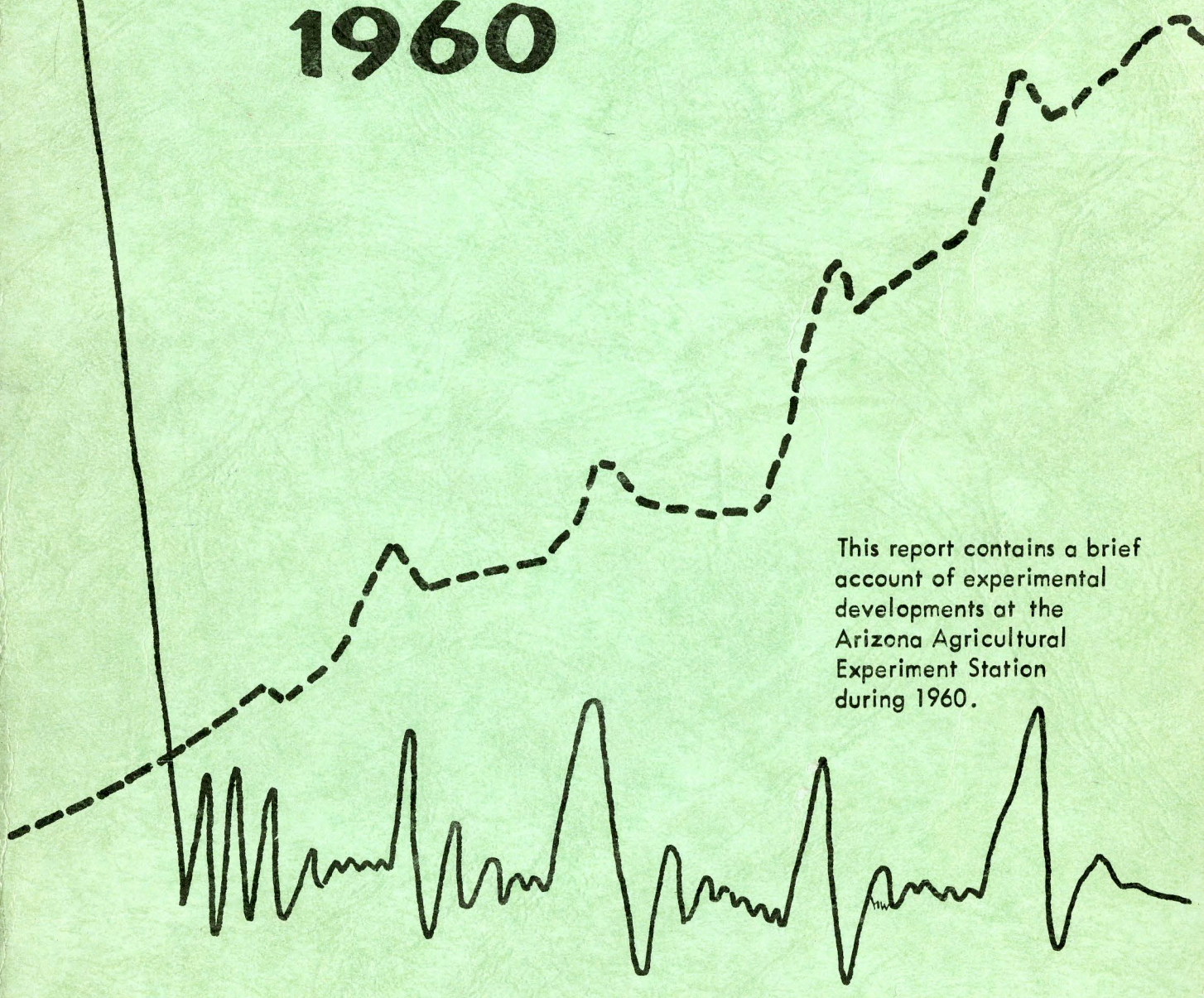
RESEARCH PROGRESS

1960



This report contains a brief account of experimental developments at the Arizona Agricultural Experiment Station during 1960.

AGRICULTURAL EXPERIMENT STATION

THE UNIVERSITY OF ARIZONA

Tucson

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This publication is prepared primarily for the internal use of the College of Agriculture, The University of Arizona, and for those individuals and institutions particularly concerned with the progress of research at the Agricultural Experiment Station for the period between January 1 and December 31, 1960.

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Watershed Management

Department of
AGRICULTURAL BIOCHEMISTRY

1. PHYSIOLOGICAL AVAILABILITY OF AMINO ACIDS AND OTHER NUTRIENTS IN FOODS AND FEEDS.

Project Number: 258-A. Funds: Hatch. Personnel: M. G. Vavich, A. R. Kemmerer, F. Armstrong, A. A. Kurnick, and B. W. Heywang. (In cooperation with Department of Poultry Science and the Southwest Poultry Experiment Station.)

Four trials at two locations (Glendale and Tucson) were completed comparing the requirement of growing chicks for vitamin A in hot weather and cold weather. Stabilized vitamin A concentrates was supplied in the diet at the rate of 500, 750, 1000, 1250, 1550, or 3000 I.C.U. per pound of feed. Liver storage of vitamin A increased as the level of dietary vitamin A was raised. Statistical evaluation of liver vitamin A storage at one location (Glendale) showed no consistent differences among groups according to season.

2. THE NUTRITIVE VALUE OF SOUTHWESTERN PRODUCED FOODS AND FACTORS AFFECTING THESE NUTRITIVE VALUES.

Project Number: 258-C. Funds: Hatch. Personnel: M. G. Vavich, A. R. Kemmerer, W. F. McCaughey, D. L. Schneider, M. R. Smith, W. S. Fleming, B. W. Heywang, A. A. Kurnick, and H. E. Nordby. (In cooperation with Southwest Poultry Experiment Station and Department of Poultry Science.)

Comparison of rat growth on diets containing 30% honey from 6 floral sources with isocaloric sucrose diet showed significant growth increases of the rats fed honey. The percentage composition of the carcasses from both the honey and sucrose groups did not differ appreciably in fat or protein.

Preliminary work with the anti-wrist-stiffness factor for guinea pigs indicates qualitative presence in buckwheat and sweet clover honeys.

Work was continued on concentrating the cyclic fatty acid from cottonseed oil responsible for the pink discoloration phenomenon of stored eggs.

A similar fatty acid fed in the form of the oil from Sterculia foetida decreased hatchability of eggs to 18% when fed at the rate of 25 mg. daily to laying hens.

3. THE INFLUENCE OF THE INTERRELATIONSHIP OF FOOD FACTORS UPON PHYSIOLOGICAL UTILIZATION OF CAROTENE AND VITAMIN A.

Project Number: 271. Funds: Hatch. Personnel: A. R. Kemmerer and M. G. Vavich.

100 ug. beta carotene in conjunction with 1 unit of insulin or 1 mg. carotene or a combination of the two was given to weanling rats. Liver storage of vitamin A was low because of the percentage of Cis isomer in the beta carotene. As was reported last

year cortisone reduced the liver and kidney storage of vitamin A. Insulin in contradiction to last year's work raised the liver and kidney storage of vitamin A. Insulin and cortisone given together reduced storage of vitamin A but did not counteract each other.

Fecal carotene analyses showed that these effects were not due to lowered digestibility of carotene.

4. POLLEN SUBSTITUTE FOR HONEYBEES

Project Number: 382. Funds: Hatch. Personnel: A. R. Kemmerer, W. F. McCaughey, F. E. Todd, and L. N. Standifer. (In cooperation with Bee Culture Laboratory, U.S.D.A.)

Fecal nitrogen excretion was determined for newly-emerged honeybees fed diets of 5% protein as pollen, egg albumin, soy hydrolysate, or casein for 7 days. Bees fed pollen showed, as % of total N: uric acid 61.30, creatine 3.71, creatinine 5.29, alpha-amino N 6.11, urea 0, and NH_3 0. Uric acid excretion varied inversely with adequacy of dietary protein, amounting to 96.27% of total N excreted by the negative control. Alpha-amino N excretion showed a direct relationship, amounting to 1.36% and 6.11% of total N respectively for negative control and pollen-fed group. No consistent variation observed for other excreted N compounds. Free amino acids in several pollens have been determined by col. chromatography: in addition to the usual 18 amino acids found in hydrolyzed pollen protein, hydroxyproline occurred in Ranunculus pollen and citrulline is suspected in 3 others. No significant differences in pharyngeal gland development were observed when caged bees were fed egg albumin, dehydrated whole egg, Balsamorrhiza sagittata pollen, or cactus pollen for 7 days at the 10% protein level, and all showed excellent gland development. Attempts to extract the protein fraction from several pollens treated with cellulase or hemicellulase enzymes to penetrate the pollen grain cost were not successful when measured electrophoretically.

5. AMINO ACID PROPORTIONS AND BIOLOGICAL UTILIZATION OF PROTEINS IN SORGHUM GRAINS

Project Number: 464, (W-57). Funds: Hatch and State. Personnel: M. G. Vavich, A. R. Kemmerer, and B. W. Heywang. (In cooperation with Southwest Poultry Experiment Station, Glendale.)

The biological value of the protein of four varieties of sorghum grains (Hegari, Double Dwarf Milo, Hybrid Milo, and Marlin Milo) and corn were compared. Chicks were used as experimental animals and the main source of protein in the ration came from 24% soybean meal. The sorghum and corn furnished approximately 7% protein. The amount of protein furnished by these grains in each was equalized in each ration with fish meal and the energy (1040 cal. per pound) was equalized with cottonseed oil. With these circumstances the protein in all four of the sorghum grains were significantly inferior to corn. With male chicks only, Double Dwarf Milo was significantly better than the other three milos.

Energy intake was found to be an important factor in the experiments. When only protein was equalized the protein in Hegari was equal in biological value to that of corn. However, when energy intake was equalized Hegari protein proved inferior to that of corn.

6. CROSS-LINKING OF COTTON TO PRODUCE A WASH-AND-WEAR TYPE OF FABRIC.

Project Number: 453. Funds: State Research. Personnel: Archie J. Deutschman, Jr. and Henry W. Kircher.

Reaction of carbohydrates with acetylene to produce starting materials for plastics and other chemical intermediates has yielded a number of new chemicals. The USDA is in the process of preparing a contract to support an extension of the work to starch and other intermediates. Cottonseed meal has been treated and fed to chickens and none of the harmful effects normally associated with the use of this material noted. The separation of acetylated sugars has been achieved by gas chromatography. Two papers have been published and one has been submitted for publication. A chapter has been prepared for publication in a book on gas chromatography.

7. TISSUE CULTURE INVESTIGATIONS IN RHEUMATOID ARTHRITIS.

Project Number: A-2520. Funds: U. S. Public Health Service. Personnel: C. A. L. Stephens, M.D., A. R. Kemmerer, A. B. Stanfield (Project Leader), M. E. Crawford, J. P. Bailey, E. A.Henthorn, and R. A. Hartline. (In cooperation with Southwestern Clinic and Research Institute, Inc.)

During the two years of operation on above grant, tissue cells have been successfully cultured from 150 synovia both from patients with rheumatoid arthritis and from non-rheumatoid individuals, and from 25 synovial fluids. Cultural and morphological differences have been studied and results recorded by tine-lapse cinephotomicrography, still photomicrographs, stained preparations, etc. Strains have been developed and maintained successfully in continuous propagation from one R.A. and 3 Non-R.A. cultures. In addition to R.A. and Non-R.A. sera, material used for challenge of cells has included breia from bursae; nodulea; spleens; and buffy coat. Assessing the cytopathological effects of material on heterologous cell cultures is difficult. Inasmuch as our ultimate goal is to challenge R.A. cells with various cellular fractions, cloning of cells from primary synovial cultures will be attempted so the effects on each type may be readily evaluated. Delayed hypersensitivity is characterized by a lymphocyte transfer facts and the absence of serum antibodies. Extensive studies are underway to challenge active cultures with intact and fractured lymphocytes in an attempt to demonstrate the presence of a transfer factor.

8. MUTATION STUDIES WITH TOBACCO MOSAIC VIRUS.

Project Number: 873. Funds: AEC Contract AT(11-1). Personnel: Albert Siegel, Milton Zaitlin, and Shirley Stigers.

Attempts have been made to find mutagenic agents for tobacco mosaic virus other than nitrous acid. These attempts have not as yet proved successful although the

results of preliminary experiments using the ethylating agent, ethyl methanesulfonate look promising.

A technique for separating the cells of plant leaves from each other with a crude pectinase preparation has been developed by Dr. Milton Zaitlin. In order to preserve the integrity of the cells, attempts have been made to purify the enzyme responsible for cell separation and to study its specificity. To date an hundred-fold enrichment of the enzyme preparation has been accomplished. The enzyme appears to be a polygalacturinase. Other enzymes with polymethylgalacturinase activity are inactive in separating cells. Thus, the "glue" that holds leaf cells together appears to be a non-methylated pectin.

Separated tobacco leaf cells when incubated under appropriate conditions produce a substance which inhibits the infectivity of tobacco mosaic virus. This inhibitor acts to block the sites on a leaf which are subject to infection with the virus. This inhibitory substance is presently being characterized. Preliminary tests reveal that it may be a lipoglucan.

9. THE REIATIONSHIP BETWEEN RIBONUCLEIC ACID AND PROTEIN.

Funds: NSF-G13723. Personnel: Albert Siegel and Milton Zaitlin.

Tobacco mosaic virus has been treated with the mutagenic agent nitrous acid. The action of the agent results from the deamination of the base residues of ribonucleic acid which is the genetic material of the virus. Twenty mutants isolated after nitrous acid treatment of the virus have been examined for alterations in the protein moiety of the virus by a peptide mapping technique. The results to date reveal that two of the twenty viral proteins examined are different from the proteins of the parent strain. The nucleic acid of the virus contains 6,600 nucleotides whereas the protein moiety contains 157 amino acids. Our results argue that roughly only a tenth of the nucleotides are concerned with mapping the protein of the virus. This conclusion is compatible with the notion that only three to four nucleotides are responsible for coding each amino acid in a polypeptide.

Department of
AGRICULTURAL CHEMISTRY AND SOILS

1. WEATHER (IN COOPERATION WITH THE U. S. WEATHER BUREAU).

Project Number: 160. Funds: State. Personnel: H. V. Smith and Student Assistant.

The year of 1960 was one in which the mean temperatures exceeded the long-time averages by more than 1.5 degrees Fahrenheit. The month of March had the greatest deviation from normal, with the temperatures averaging 5.5° F above normal for the month. Also of interest is that the all-time high of 112° was exceeded by 1 to 3° during June of this year. The new record was a part of a protracted warm period in late June and early July during which maximum temperatures exceeded 100° for 21 consecutive days.

On the other hand, the lowest temperature for the year occurred in early December. The temperature was 21°. Such temperatures are not unusual but in this case the temperature remained below 25° for nine hours which accounts for the rather severe frost damage to the local vegetation.

Furnished monthly weather reports to the U. S. Weather Bureau for inclusion in their publication "Climatological Data, Arizona."

2. NUTRITIONAL, CHEMICAL AND PHYSICAL STUDIES ON THE MORE IMPORTANT SOIL TYPES IN ARIZONA.

Project Number: 265. Funds: Hatch and State. Personnel: H. V. Smith, G. E. Draper and T. F. Buehrer. Cooperators: G. F. Kester (SCS) and John Retzer (USFS).

Chemical and physical determinations have been made on soil survey samples taken in Arizona during past years, as part of the fertility inventory contemplated under this project. The determinations include: conductivity of the saturation extract, concentrations of the various cations and anions present in the 1:5 extract, pH determinations on the soil paste, cation exchange capacity and exchangeable cations. Approximately 2,000 samples have been partially analyzed in the laboratory.

The results of a study of two soils, Mohave and McClellan, in the Salt River Valley to determine the cause of the high degree of natural surface compaction, were assembled for publication. Degree of compaction gave a highly significant correlation, positive for illite content and negative for montmorillonite content, in the colloidal clay fraction. "Hardspots" are shown to be areas where the subsoil had been exposed in land-leveling operations.

A paper entitled: "Factors affecting aggregation and Permeability of Hardspot Soils," authored by T. F. Buehrer and J. M. Deming, has been accepted for publication in Soil Science some time during 1961.

3. FERTILITY REQUIREMENTS OF CROPS ON ALKALINE-CALCAREOUS SOILS OF DIFFERENT TYPES, UNDER SEMI-ARID AND IRRIGATED CONDITIONS.

Project Number: 266. Funds: Hatch and State. Personnel: T. C. Tucker, Fred Turner, H. F. Kreizinger, J. L. Abbott, E. W. Carpenter and B. R. Gardner.

Experiments were conducted for the most part under field conditions that related to the objectives of the project. The greatest total effort was devoted to cotton which presents more unsolved problems. With other crops the work was most directly related to Objectives (1) (Determine the nature and extent of crop response to added nutrients on soils of different characteristics.) and (2) (Evaluate the nutrient interactions and levels of responsiveness.) and in some cases to Objectives (6) (Relate crop response to nutrients, especially phosphorus, to existing and new methods of soil testing.) and (7) (Relate crop composition and tissue test to nutrient response and soil test values.)

1. Fourth Annual Arizona Fertilizer Conference Report, Feb. 1961. 2. Effect of N and P on the Plant Characteristics Related to the Yield of Barley. 3. Interrelationship of Sorghum Varieties and Nutrients. 4. Nitrogen Effects on Cotton: I. Plant Characteristics and Petiole Analysis, presented SSSA meetings, 1960, Chicago. Hay Production of Small Grains Utilizing City Sewage Effluent, Agron. Jour. V:52, 1960.

Lettuce Research in Arizona. 1960. U. A. Agric. Expt. Sta. Report #

4. THE AVAILABILITY OF NATIVE SOIL PHOSPHATE AND NEW COMMERCIAL PHOSPHATE FERTILIZERS IN ARIZONA CALCAREOUS SOILS.

Project Number: 280. Funds: Hatch, State, and California Chemical Co. Personnel: T. C. Tucker, W. H. Fuller, C. O. Stanberry, J. L. Abbott, E. W. Carpenter, and J. P. Jones.

The uptake of phosphorus by cotton from fertilizers containing 16, 45 and 100 per cent water soluble phosphorus was studied under field conditions. The materials contained P^{32} and were applied at three times during the season. Preliminary interpretation of the data suggests that more P in the plant was derived from fertilizers of low water solubility (16 and 45% WSP) when the fertilizer was applied at planting time in April. This was true for both the 46 and 138 lbs. P_2O_5 per acre rates of application. The relative amounts of the three materials taken up from the June 21 and July 19 applications were reversed from the planting time applications. That is, in the later applications, the most water soluble materials were the most effective in terms of uptake from the fertilizers. Phosphate fertilizers did not change the yield of cotton nor the total plant content of P.

In a greenhouse experiment with tomatoes, materials of lowest WSP and fine particle size were more effective than the coarse particle sizes of the same materials and at least equal to the material of highest WSP.

Evidence has been obtained in controlled leaching studies that phosphorus in organic residues moves much more readily thru calcareous soils than when applied in inorganic form.

A more thorough knowledge of the behavior of phosphate fertilizers will provide a sound basis for fertilizer use and add to the scientific knowledge accumulated.

The effect of nitrogen on the utilization of phosphorus from the soil and fertilizers as influenced by placement and fertilizer formulation will be studied under field conditions with grain sorghum.

Fourth Annual Report on Soil Fertility and Fertilizer Research. Feb., 1961. Ariz. Agr. Exp. Station and Agri. Ext. Ser., Report No. 3.

5. THE NATURE OF MICROFLORA AND THEIR ACTIVITY IN ARIZONA SOILS AS AFFECTED BY SOIL TEMPERATURE, MOISTURE, SALINITY, pH, AND OTHER FACTORS PECULIAR TO SEMI-ARID CONDITIONS.

Project Number: 283. Funds: Hatch and State. Personnel: W. H. Fuller, and Richard F. Smith.

In recent years gaseous air ions have been shown to have a number of relatively minor but precise physiological effects on mammals by Kruger and Smith, and Smith and Kruger of the University of California. The actual components of ionized air that produce these effects are known to be positively-ionized carbon dioxide and negatively-ionized oxygen. No comparable work has been done with plants. Guided by the research with mammals, the following research was undertaken. Microcoleus vaginatus (Vaucher) was obtained from the soil on the campus as a test organism. Cultures were obtained and exposed to unipolar ion densities of 1 X $18^8/cm^2/sec$. produced by an ionizer consisting of tritium in a sealed foil with a reversible rectifying circuit to permit selection of either (+) or (-) ions. Under certain conditions, ionized air is able to produce increased growth and movement in samples of blue-green algae. Two techniques for demonstrating these effects are described. A method for determining the specific component of ionized air responsible for the observed effects is reported. Evidence is presented that indicates positively-ionized CO_2 is the biologically active component of ionized air in these experiments.

Cameron, Roy and Fuller, W. H. Nitrogen Fixation by Some Algae in Arizona Soils. Soil Sci. Soc. Am. Proc. 24:353-356. 1960.

Fuller, W. H., Cameron, Roy, and Raica, Nicholas, Jr. Fixation of Nitrogen in Desert Soils by Algae. Intnat. Soil Sci. Soc. Proc. 1960.

Fuller, W. H., McAlister, D. F. and Metcalfe, D. S. Agronomy in the Southwest. Adv. in Agron. 12: 197-227. 1960.

Fuller, W. H., Johnson, G. V., and Sposito, G. Influence of Municipal Refuse Compost on Plant Growth. Compost Science. 1: 16-19, 1960.

6. A STUDY OF THE EFFECT OF TEMPERATURE VARIATION ON VARIOUS CHEMICAL AND PHYSICAL SOIL PROPERTIES WHICH AFFECT FERTILITY.

Project Number: 289. Funds: Hatch and State. Personnel: R. H. Maier and J. S. Bullock.

Mimbres loam located near Willcox, Arizona, was used in this study. The soil was prepared by crushing it with a wooden roller and passing it through a 10-mesh

stainless steel sieve. The two treatments used were as follows--control and 100 lbs. P_2O_5 per acre from 20-20-0. The fertilizer was added to the soil and mixed for 15 minutes in a plastic blender. Samples were placed into plastic tumblers, brought to 95 per cent moisture equivalent and allowed to stand 24 hours to attain equilibrium. The tumblers were placed in controlled temperature water-baths at temperatures of 5°C., 25°C. and 45°C. and held constant at these levels for two weeks. Each treatment was replicated 3 times. Ten grams of each sample was leached first with normal neutral ammonium acetate, then with 0.1 N. hydrochloric acid and finally with 20 per cent ammonium hydroxide. Little or no effect of temperature on ammonium acetate soluble phosphorus was observed in the control. When fertilizer was added, more phosphorus was extracted with hydrochloric acid from soils held at 45°C.; however, when no fertilizer was added the most acid-soluble phosphorus was found in the samples held at 5°C. The ammonium hydroxide soluble phosphorus decreased with increasing temperature in the control; however, little or no change was observed in the soil which had been fertilized. The ammonium acetate soluble potassium increased with increasing temperature. There was an increase in the acid soluble potassium with increasing temperature when 20-20-0 was added, but no change was noted in the control. There was an increase in ammonium hydroxide soluble potassium in the soil held at 45°C. When fertilizer was added, the ammonium acetate and acid soluble iron was highest in the samples held at 45°C.

An improved indicator for the chelometric titration of calcium in plant materials. Submitted to Soil Science Society of America Proceedings. (in press).

7. ARIZONA SOIL SURVEY.

Project Number: 326. Funds: State. Personnel: S. W. Buol, beginning October 1, 1960, as Experiment Station Representative, and personnel of cooperating agencies. (USDA - Soil Conservation Service, Forest Service, Agr. Research Service and Bureau of Indian Affairs.)

Participated in the progress review of the Casa Grande Valley area with SCS officials. Participated in the progress review of the East Maricopa area with SCS officials. Participated in the final review of Apache County with SCS officials. A soil genesis study of Red Desert Soils has been initiated. Sampling has been conducted to a depth of 100 inches on a Mohave sandy loam profile and Mr. Sefik Yesilsoy, an ICA supported graduate student, working for a Master of Science degree in Agric. Chem. and Soils is doing this work for a thesis problem. Work on this project began in December so no results are available for this report.

Another soil survey project has been started which will serve as a thesis problem for Mr. Ramon Corella. This problem has only recently been initiated and details are not ready for this report.

The reviews I have attended have acquainted me with the soils of the state and some of the problems of soil survey in the state. The soil genesis study of the Mohave sandy loam will aid soil surveyors by providing better interpretation of their surveys.

It is planned to continue participation in SCS reviews, aid the SCS in any way that is possible and to continue the soil genesis studies on the more predominate soils of the state to provide the background work needed for soil surveys.

8. THE INFLUENCE OF BED SHAPE, PLANTING AND IRRIGATION PRACTICES ON THE GERMINATION AND YIELD OF ROW-CROPS ON SALINE SOIL.

Project Number: 409. Funds: Hatch and State. Personnel: Fred Turner, Jr., A. A. Baltensperger, and L. C. Chapman.

Water Quality: Research continued on the effects of relatively low-salt (river) and high-salt (well) irrigation waters on the growth and yield of crops on a saline-alkali soil. No significant differences in stand and yields of barley were found in 1960. Alfalfa was seeded in the fall. Good stands were obtained. Bed-shapes: Cotton planted on conventional and lettuce-type beds germinated, survived, and yielded slightly better where planted in dry soil and irrigated up than where planted in moist soil. Forage: Of three varieties of bermuda grass planted in late 1959, Coastal out-yielded Midland and Common. Midland was slowest in spreading.

All experiments were conducted at the Branch Station, Safford, Arizona.

The results of these investigations are helpful to the farmer in better formulating his soil management programs, particularly where high-salt water and saline-alkali soil conditions exist. Expected responses to fertilizers, based on soil tests, often must be modified for saline and alkali soils. Expectations that a high quality crop can be produced economically are increased.

New equipment is now available and will be used for bed-shape investigations with cotton in 1961. Nitrogen variable will be introduced in the bermuda experiment. Water quality studies on the alfalfa continues. Sugar beet investigations will be initiated with variables of varieties and N rates. Soil and water samples are to be taken for analysis. The above is to be conducted at the Safford Station.

Some progress reports are included in the Fourth Annual Soil Fertility and Fertilizer Research - 1961.

9. BASIC PRINCIPLES INVOLVED IN TRACE ELEMENT NUTRITION OF CROPS AND AVAILABILITY IN CALCAREOUS SOILS.

Project Number: 441. Funds: Hatch and State. Personnel: R. H. Maier

Research during the past year has been concentrated on the "fate" or availability of micronutrients in plant tissue with particular attention on copper. Previous research under this project has indicated that it is extremely difficult to predict micronutrient needs of plants in relation to the soil in which the plants are grown. It has been observed that the content of certain micronutrients within the plant is not a reliable indication of the amount of the nutrient within the plant which can be utilized. Environmental factors such as chemical and physical properties of soil may modify the amount of utilizable nutrient within the plant. Chemical fractionation of tomato stem and leaf tissue by solvents of decreasing dielectric constant (increasing solubility of organic forms) indicate that approximately 50% of the total copper is present in strongly bound organic form. At the present time there appears to be a different fractionation pattern for stem and leaf tissue.

Edwin B. Kurtz, Jr., and R. H. Maier, Acid Chlorosis and Iron Uptake by Sorghum (Double Dwarf-38) Grown in Solution Culture. Agron. Jour. 52: 486-487, 1960.

Reprinted from the AGRONOMY JOURNAL
Vol. 52:486–487, 1960.

Acid Chlorosis and Iron Uptake by Sorghum (Double Dwarf-38) Grown in Solution Culture[1]

Edwin B. Kurtz, Jr., and R. H. Maier

LARGE amounts of sorghum (*Sorghum vulgare* var. Double Dwarf-38) are grown in Arizona. On the basis of nutrient solution studies, this variety appears to be well-suited for growing on the alkaline soils of that state. That is, plants grown in sand culture on nutrient solutions adjusted to pH 8.0 and 9.5 were green, vigorous, and produced abundant seed, whereas those grown on nutrient solutions of pH 5.0 and 6.5 were severely chlorotic and showed typical iron deficiency symptoms (figure 1).[2] All culture solutions contained only 0.5 ppm iron in the form of tartrate. A group of chlorotic sorghum plants growing on the pH 6.5 solution was supplied with nutrient solution containing 10 ppm iron in the form of ethylenediamine di(o-hydroxyphenylacetic acid) (EDDHA). These plants overcame their chlorosis indicating further that the acid chlorosis, that is, the chlorosis of plants grown in nutrient solutions of pH 7.0 or less, was due to either lack of uptake or disturbed metabolism of iron. The objective of the present paper was to determine the pattern of iron uptake of this variety of sorghum as a function of pH of the nutrient solution.

Seeds of sorghum (Double Dwarf-38) were planted in the greenhouse in black, plastic, quart pots containing perlite as a physical supporting medium. Each pot had a drainage outlet. Complete nutrient solutions[3] were adjusted with NaOH or HCl to pH 3.0, 4.0, 5.0, 6.0, 6.5, 7.0, 7.5, 8.0, 9.0, and 10.0. Each pH treatment consisted of 4 or 5 pots. After germination each pot was thinned to one plant.

[1] Contribution from the Arizona Agricultural Experiment Station, Technical Paper No. 552. Received Oct. 30, 1959.
[2] Kurtz, E. B., Jr. Sorghum nutrition. Prog. Agr. in Ariz. 10:10. 1958.
[3] Hoagland, D. R., and Arnon, D. I. The water-culture method for growing plants without soil. Calif. Agr. Exp. Sta. Cir. No. 347. Revised, 1950.
[4] Maier, R. H. Wet-ashing of plant materials. Dept. Agr. Chem. and Soils Mimeo, Univ. of Arizona, Tucson. 1958.
[5] Snell, F. E., et al. Colorimetric Methods of Analysis, Vol. IIA.D. Van Nostrand Co., Inc., Princeton, N. J. 1959.

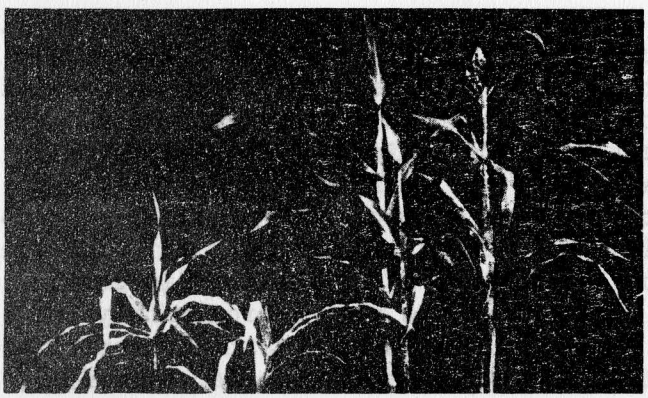

Figure 1—Effect of pH on growth and chlorosis of sorghum, variety Double Dwarf-38. The pH of nutrient solutions were, left to right, 5.0, 6.5, 8.0, and 9.5.

Table 1—Effect of pH of the nutrient solution on growth and iron uptake by sorghum (Double Dwarf-38).

pH	Plant part	Dry weight, grams	Total iron µg.	Iron, ppm. dry weight basis
3.0	Leaf blades	0.45*	29.8*	66.2
	Stem	0.15	7.4	49.3
	Total	0.60	37.2	62.0
4.0	Leaf blades	0.19	16.1	84.7
	Stem	0.08	7.8	97.5
	Total	0.27	23.9	88.5
5.0	Leaf blades	0.16	14.7	91.9
	Stem	0.05	5.0	100.0
	Total	0.21	19.7	93.8
6.0	Leaf blades	0.29	21.0	72.4
	Stem	0.20	9.3	46.5
	Total	0.49	30.3	61.8
6.5	Leaf blades	0.27	15.0	55.6
	Stem	0.15	6.2	41.3
	Total	0.42	21.2	50.5
7.0	Leaf blades	1.05	66.1	63.0
	Stem	0.46	16.8	36.5
	Total	1.51	82.9	54.9
7.5	Leaf blades	0.82†	77.5	94.5
	Stem	0.33	17.2	52.1
	Total	1.15	94.7	82.3
8.0	Leaf blades	1.32	98.4	74.5
	Stem	0.64	29.5	46.1
	Total	1.96	127.9	65.3
9.0	Leaf blades	1.83	137.2	75.0
	Stem	0.70	30.1	43.0
	Total	2.53	167.3	66.1
10.0	Leaf blades	1.65	163.5	99.1
	Stem	0.60	34.5	57.5
	Total	2.25	198.0	88.0

* Means of four or five plants. † Majority of plants were diseased.

The plants were watered daily with the nutrient solution but later the larger plants were watered twice daily. After the plants were 15 days old, distilled water was used every 7 days to flush out the pots.

Nine days following emergence, plants at pH values of 3, 4, and 5 showed slight chlorosis. Twelve days following emergence, plants in solutions with pH from 3 to 7 showed chlorosis. When the plants were harvested (five weeks old), the sorghum growing in the alkaline nutrient solutions had little or no chlorosis. But those plants growing in acid solutions had considerable amounts of yellowing and were stunted severely.

When the plants were five weeks old, they were harvested by cutting the stems at the level of the perlite and separating each plant into leaf blades and stem (including sheaths) portions. Plant material was dried at 70° C. for 48 hours, weighed, and ground in a Wiley mill to pass a 40-mesh stainless steel screen. The plant material was wet-ashed[4] and iron was determined by an o-phenanthroline method.[5] Where possible, each chemical analysis was done in duplicate.

As shown in table 1, dry weights of plants grown in the neutral and alkaline solutions were larger than those plants from acid solutions. Also, the total amount of iron in the leaf blades and entire shoot of the plant was larger in the sorghum grown in the neutral and alkaline solutions than in the acid solutions. Although there was an increase in the amount of total iron in the stem and sheaths of plants grown in neutral and alkaline culture solutions, the degree

of alkalinity of these solutions apparently did not impair the translocation of iron from the stem and sheaths into the leaf blades.

At the present time it is difficult to explain these results. Absorption of iron by the roots or movement of iron to the shoot may be impaired in the acid solutions. Wiklander[6] has reported the existence of ions such as $FeOH^{++}$ and $Fe(OH)_2^{+}$, and it is possible that alkaline conditions might produce these soluble ions and thereby render iron more available for uptake by certain plants. It may also be possible that this variety of sorghum excretes natural chelating agents which solublize iron from such insoluble compounds as iron hydroxide, phosphate, and carbonate.

Additional investigations are under way to further compare and possibly explain the iron chlorosis of this sorghum variety and to compare this variety with other varieties of sorghum and other plants.—EDWIN B. KURTZ, JR., *Associate Botanist, Department of Botany, and* R. H. MAIER, *Associate Chemist, Department of Agricultural Chemistry and Soils.* *Appreciation is expressed to N. S. McNutt for the chemical analyses.*

[6] Wiklander, L. Cation and anion exchange phenomena. In—"Chemistry of the Soil," edited by F. E. Bear. Reinhold Publ. Corp., New York. pp. 137. 1955.

11. NON-SYMBIOTIC NITROGEN FIXATION BY AIGAL CRUSTS AND THEIR CONTRIBUTIONS TO THE SOIL NITROGEN OF SEMI-ARID SOILS.

Project Number: 443 (W-31). Funds: Regional Research and State. Personnel: Nicholas Raica.

Waxed pint cartons containing washed quartz sand were planted in ryegrass with either algal tissue or soil crust introduced at the time of planting. There was appreciable uptake of algal tissue nitrogen (N^{15} labelled) in the first two weeks. Crusts inhibited growth through competition for NO_3-N. With N-free media crusts contributed nitrogen. Selected sites are being evaluated for long-term changes in inorganic and organic forms of nitrogen. Preliminary data indicates that raw crusts do incorporate N_2^{15}. Since intact algal cells are difficult to extract quantitatively, methods/modifications are being evaluated for maximum efficiency and yields.

Work will be continued to study: a. nitrogen changes in algae encrusted soils, b. nitrogenous excretion/decomposition products of algae, c. environmental effects on algal pigments.

12. SOIL AND WATER TESTING.

Project Number: 455. Funds: State. Personnel: H. V. Smith, G. E. Draper, T. F. Buehrer, L. Amburgey, H. Corrie, and M. Riggs.

The foremost duty of the laboratory is to test soils and waters for farmers. Other responsibilities are to test soils and waters for the Experiment Station, the Soil Conservation Service, students and other individuals and agencies. During 1960, samples were analyzed as follows: SOILS: Total - 2133; Farm and Home 733; Experiment Station 716; S.C.S. 496; Soil Survey 147; Mexico 41. WATERS: Total - 868; Farm and Home 555; Exp. Station 78; S.C.S. 186; San Pedro 15; U.S.G.S. 21; City of Tucson 13.

Methods of analyses have been examined critically and changes made in procedures wherever justified. It was found that chlorides do not seriously interfere with the nitrate determination unless present in excess of 4 milliequivalents per liter. It was found that Calgon could be substituted for laboratory-prepared sodium hexameta-phosphate as a dispersing agent. After comparing the Bouyoucos and Day procedures for making mechanical analyses, the Day procedure was adopted as being the superior method. Erratic results in the dispersion percentage determination were found to be due to the manner in which the soil and water are mixed. A standard procedure was developed which eliminated this variability.

The value of having high quality irrigation and domestic waters is so well known that it need not be discussed here. The usefulness of the laboratory findings are evident when the quality of water is the basis of determining whether a water may be used for a given purpose. Laboratory analyses are used to determine the suitability of soils for cultivation. The appraisal may be based on the salinity, alkalinity or pH of the soil as well as texture, fertility elements and moisture relationships.

The work planned for next year will be similar to that done this year.

Preparation of three publications is in progress. They are as follows:
1. Quality of Arizona's Domestic Waters.
2. Quality of Arizona's Irrigation Waters.
3. Laboratory Manual of Analytical Methods Used in the Soil and Water Testing Laboratory.

13. WATER AND ION MOVEMENT IN SOILS AND PLANTS.

Project Number: 472. Funds: State. Personnel: C. O. Stanberry and D. M. Anderson.

Under variable levels of moisture and nutrient concentrations, growth of red kidney beans, dicotyledons, and the above-ground plant-content of N, P, and K were studied for a period of 11 days, using a composite rotatable design. Results were plotted as response surfaces. It was found that changes in the slopes and/or types or curves with increasing nutrient concentrations raises serious questions as to the significance of previous work. Extrapolation of data obtained into unexplored regions was avoided because of the changing curves. It is believed that one dares use such data only under the conditions administered, and only within the limits of variables explored. There even may be danger within such limits, certainly if more than one type of curve results, because the calculated equation gives only the best fit for the general response obtained. ...From this work it appears that the composite rotatable design is excellent for qualitative results, involving a minimum of work in relation to data obtained. It may be necessary to conduct sequential tests to determine optimum rates of variables, the response surface near optimal conditions, and for quantitative or semiquantitative results. Sequential tests require carefully controlled conditions so that repeated tests are comparable. Data diagnosis may be considered difficult since the extensive use of higher Calculus is involved.

Experimental work concerning soil moisture and nutrient concentration and their interactions on ion uptake is difficult, covers a problem of great practical importance, and one commonly over-simplified and misunderstood. This research indicates the complexity of the problem, the reason for some common misunderstanding, and suggests a more suitable method of approach.

By using autoradiographic techniques, phosphorus movement in three soil textures is planned for 1961, with irrigation as a variable also.

Two manuscripts resulting from the above are in preparation: Nutrient Uptake by Plants as Influenced by Moisture and Nutrient Levels by E. V. Maas and C. O. Stanberry; and Determination of Nitrogen, Phosphorus and Potassium in a Single Wet-Digestion of Plant Material by C. O. Stanberry and E. V. Maas.

14. MECHANICS OF SOIL AGGREGATION AND DISPERSION.

Project Number: 487 (W-66). Funds: Regional Research and State.
Personnel: D. M. Anderson and George F. Leaming.

Redesign, construction and testing of the gas adsorption apparatus previously employed in these studies have resulted in a greatly improved experimental method for studying gas adsorption and solid-gas reactions in soils. The amount of adsorption or the extent of reaction is determined gravimetrically instead of volumetrically as has hitherto been customary.

Lyophilized, thixotropic, bentonite gels were examined by ordinary and electron microscopy in an effort to discover the nature of the particle interactions. Although inconclusive and as yet incomplete, the results obtained indicate that edge to face contacts between the solid phase are indeed present and could account for the gel strength.

Publication: A Volumetric Study of Some Thixotropic Sodium-Bentonite Suspensions, D. M. Anderson and G. F. Leaming. (in press).

15. A STUDY OF THE MECHANICS OF UNSATURATED FLOW OF WATER IN SOILS.

Project Number: 488 (W-68). Funds: Regional Research and State.
Personnel: D. M. Anderson, F. A. Linville, L. M. Parks, R. C. Jones.

Temperature fluctuations at a wetting front were studied. Temperature fluctuations exceeding 20°C were observed under favorable conditions during infiltration of dry Arizona bentonite. Vapor flow was distinguished from liquid flow, and flow rates were studied at different temperatures to determine the activation energies characteristic of these two flow processes. Preliminary results suggest that the liquid flow has an activation energy characteristic of viscous flow, but that the activation energy of a magnitude equal to the energy of vaporization of water. Evidently the rate of vapor movement is dependent upon the rate of evaporation at the advancing liquid front. These results are now being incorporated into the further development of the theory of infiltration.

Publication: Temperature Fluctuations at a Wetting Front I. Characteristic Temperature-Time Curves, D. M. Anderson and F. A. Linville. (in press).

16. INTERRELATIONSHIPS OF SOIL MOISTURE AND TEMPERATURE ON PLANT GROWTH AND PHYSIOLOGICAL FRACTIONS.

Project Number: 489 (W-67). Funds: Regional Research and State.
Personnel: R. H. Maier and S. Shammoot.

Two Arizona soils were each maintained at 70 and 95% of their respective moisture equivalents at each of three soil temperatures; namely, 5°, 25°, and 45°C for a period of two weeks. The soil treatments consisted of two magnesium levels. Following incubation, cation exchange capacity, organic carbon, pH value,

ammonium acetate (pH 7.0) - soluble calcium and magnesium and ammonium acetate (pH 3.0) - soluble iron were determined in all soils. Essentially there were no pronounced effects of soil moisture - temperature treatments on any of the above chemical conditions measured.

17. THE UPTAKE OF STRONTIUM BY VARIOUS TYPE CROPS AND FACTORS AFFECTING UPTAKE AND TRANSLOCATION OF STRONTIUM AND CALCIUM NATIVE IN SOIL (IN COOPERATION WITH THE UNITED STATES ATOMIC ENERGY COMMISSION).

Funds: U. S. Atomic Energy Commission and State. Personnel: W. H. Fuller, R. J. Hannapel, Gordon V. Johnson, and Shirley Bosma.

The effect of various crop residues, soil amendments and agricultural chemicals on the movement of surface contamination of radiostrontium was studied in columns of Superstition sand. The movement and distribution of decomposing crop residues contaminated with absorbed radioactive strontium, calcium and phosphorus was also investigated. Since it was considered that movement of contaminating radioactive elements may be related to the concentration of calcium in the soil solution, total calcium was determined on the leachates discharged at the bottom of the 8-inch soil column. The three radioactive elements, Sr-89, Ac-45, and P-32 were applied to the surface or mixed into the upper one inch of the soil both in organic crop residues or as inorganic acids or salts.

The most prominent findings were that the tagged elements moved through the soil most readily when they had been incorporated into organic residues than when applied as soluble inorganic salts or acids. Moreover, applied inorganic strontium as well as soil calcium moved more readily when plant residues or acetic acid was added than when agricultural amendments and chemicals were added. There is strong evidence that all 3 elements move through the soil more readily when in organic than inorganic combination. Most of the soils of arid and semi-arid lands contain free calcium carbonate. Since calcium and strontium are absorbed equally well by crop plants and do not distinguish between the two elements, it was expected that calcium salts in calcareous soils would compete directly with sources of contaminating radiostrontium. Experiments were conducted to determine why $CaCO_3$ (lime) would not compete with radiostrontium in soils. Data are presented again to show that $CaCO_3$ does not compete well when a soluble source of Ca, such as exchangeable soil Ca is present. In sand cultures where soluble Ca is not present, plants do use Ca from the carbonates. The hypothesis is presented that Ca of calcium carbonate will not compete with soluble calcium salts or exchangeable soil Ca except when this form of Ca is limited in amounts in soil.

18. EXISTENCE OF MICRONUTRIENT FRACTIONS IN PLANTS (IN COOPERATION WITH THE NATIONAL SCIENCE FOUNDATION).

Funds: Grant, National Science Foundation. Personnel: R. H. Maier and Ray Cattani.

Iron chlorotic plants very often contain more total iron than healthy plants. It has been postulated here that one reason for the chlorotic condition of a plant may be because of the localization of the iron in particular areas within the intercellular components of the plant. Although a chlorotic plant may

have more total iron than a "healthy plant," it seems reasonable that the intercellular distribution of iron in chlorotic plants may vary greatly from healthy plants. Any variation in the intercellular distribution of iron between chlorotic and healthy plants could be the cause (if not the result) of the chlorotic condition.

This project was initiated to study the relationship of micronutrient accumulation in intercellular plant parts between chlorotic and healthy plants. Tomato plants have been grown in hydroponic solutions in the greenhouse in (a) complete nutrient solutions, (b) iron deficient nutrient solutions and (c) copper deficient nutrient solutions. These plants were harvested at three stages of growth. On harvesting, the separate tissues (leaf, stem, and root) were quick-frozen in dry ice, freeze-dried in a lyophilizer, and stored in a freezer. Some of the tissue has since been homogenized in a sucrose buffer solution to allow collection of the various intercellular components by differential centrifugation in a refrigerated centrifuge. Total iron and total copper are being analyzed on these intercellular fractions. Preliminary data indicate a differential distribution of iron within the intercellular fractions.

19. THE EFFECTIVENESS OF POLYETHYLENE IN THE CONSERVATION OF SOIL MOISTURE AND IMPROVEMENT OF CROP PRODUCTION.

Funds: U. S. Industrial Chemicals and State. Personnel: D. M. Anderson and Rollin C. Jones.

The effects of using polyethylene coverings to enhance or prohibit seed germination and seedling survival were studied in a small-plot experiment. The results of two years testing of the influence of various polyethylene coverings on seed germination and seedling survival may be summarized as follows:

1. Germination under all films was better as a general rule than in uncovered control plots.
2. No significant differences among the various colored and clear films were apparent in enhancing germination.
3. For temperature sensitive seeds such as cotton and lettuce, germination may be enhanced by film coverings at appropriate times of the year when the uncovered soil temperature is either too cold or too hot for optimum germination.
4. Seedling survival was best under white, ivory, and clear films, less good under tan films; virtually no seedlings survived under any of the various black films tested.

A study of the effects of the various types and colors of polyethylene films on soil temperatures was begun but is not yet completed.

Publication: An Inexpensive Control Circuit for Mercury Thermoregulators, D. M. Anderson and R. C. Jones. (in press).

20. MAGNESIUM STATUS OF SOME ALKALINE, CALCAREOUS SOILS. (IN COOPERATION WITH INTERNATIONAL MINERALS AND CHEMICAL COMPANY.)

Funds: International Minerals and Chemical Company. Personnel: R. H. Maier and B. D. Knezek.

Investigations of the past year have been centered around the chemical status of magnesium in plants with respect to soil magnesium. Tomato (var. Early Pack) and Cotton (var. Ocala) were the test plants. These plants were seeded in Superstition sand and Laveen loam with varying magnesium treatments. The plants at harvest were separated into leaf and stem portions, freeze-dried, and analyzed for total, water-soluble, and acid-soluble magnesium, calcium and potassium. Most of the analytical work has been completed and is now being compiled for interpretation. Cursory examination indicates a difference in chemical forms of magnesium in leaf tissue as compared to stem tissue.

21. NITROGEN SOURCE AND TIME OF APPLICATION ON COTTON. NITROGEN IN RELATION TO COMPOSITION, VEGETATIVE AND FRUITING HABITS OF COTTON.

Funds: United States Steel Corporation. Personnel: T. C. Tucker and B. R. Gardner.

Ammonium nitrate, ammonium sulfate, calcium nitrate, anhydrous ammonia, and urea were compared on cotton at two moisture levels and applied as June side dress and preirrigation applications. This was the third year of a three year study of N sources on cotton. The effect of sources or time of application was not significant. Yield responses were obtained for each increment of applied N.

The effect of N and timing of N application was studied on cotton. Some differences in boll and fiber properties were detected as a result of N application, but were largely a result of extreme N deficiency compared with some or adequate N. Such differences would not be expected to occur under field conditions because some N is added or supplied by the soil. Petiole nitrate was affected by timing of N application. Total flowers and bolls produced as well as yield were increased by N application. Nitrogen response appeared to be related to initial soil nitrate content at planting time.

The fact that N sources were equally effective is of economic importance to the cotton grower, since sources vary considerably in price. Data obtained on the specific effects of N on cotton has immediate practical implications and adds to the scientific knowledge of the N nutrition of cotton.

The effect of soil N level on the importance of timing the N application at different physiological stages of plant development will be studied in more detail. The source study will be terminated.

Fourth Annual Report on Soil Fertility and Fertilizer Research, Feb. 1961.
Nitrogen Effects on Cotton: I. Plant Characteristics and Petiole Analysis. Presented at SSSA Meetings, Chicago, Dec. 5, 1960.

22. FORCES OF INTERACTION BETWEEN FINELY DIVIDED SILICATE PARTICLES.

Funds: National Science Foundation and State. Personnel: D. M. Anderson.

Equipment was assembled, and preliminary studies of the nature of the Coulomb and van der Waals forces of attraction and repulsion between soil particles were begun. An electrodynamic containment system for suspending charged particles in vacuo was constructed. Measurements of the charge to mass ratio of soil particles have been made. It has been determined that dry soil particles may carry a charge of either negative or positive sign and that the charge to mass ratio commonly varies between 0 and 0.005 coulombs/kg.

This study is expected to result in a significant contribution to our knowledge of the mechanisms of aggregation and dispersion in soils.

23. EVALUATION OF PLANT NUTRIENT STATUS BY SOIL AND TISSUE ANALYSES.

Funds: National Plant Food Institute. Personnel: T. C. Tucker, Graduate Assistants, and Student Technicians.

Soil and plant samples were studied in relation to yield response to fertilizer application. Preliminary results indicate the best relationship between soil nitrate and actual yield without fertilizer. Cotton petiole analysis for nitrate appears to be a good indicator of plant nitrogen status. Phosphorus analyses of plants and soil will continue as well as the nitrogen study. Current results for phosphorus are inconclusive.

24. VITAMIN C AS AN ANTI-GROWTH AGENT IN TISSUE GROWTH.

Project Number: 2RC-PHS-155 (431). Funds: U.S. Public Health Grant. Personnel: R. H. Maier and J. Irwin.

This project was initiated in June, 1960 with sweet corn, var. Asgrow Golden 22, as the test plant. In a single-ear variety of corn, the second ear develops to a certain extent and then ceases further development. If the first ear is removed from the plant at the silking stage, the second ear then resumes development similar to a "normal" first ear. This is similar to apical dominance. Previous research has indicated that ascorbic acid may be related to tissue growth. Therefore, the primary objective of this research is to relate ascorbic acid content of tissue to functicnal and non-functional tissue. Catalase and peroxidase, important enzymes in plant metabolism are also being followed in all tissues. All plant tissues for the above phase have been grown and collected and are being analyzed for ascorbic acid, catalase, and peroxidase.

25. THE USE OF PLANT TISSUE TESTING TECHNIQUE IN THE PREDICTION OF FERTILIZER NEED FOR COTTON AND OTHER CROPS.

Funds: Grant-in-Aid, Private Fund, and State. Personnel: Ellsworth Shaw and Student Assistant.

Several hypotheses were formulated on the basis of experimental data, concerning conditions and a method by which field-grown barley plants could be economically sampled for nitrate nitrogen and acetic acid-soluble phosphorus concentration. Several hypotheses were developed concerning relationship of nitrate nitrogen concentration found in plants to their nitrogen nutritional status. Field observation and experimental work along similar lines were also performed on many cotton fields.

Plant Tissue Testing to Evaluate Fertilizer Practice on Barley; manuscript prepared for review of publication.

Department of
AGRICULTURAL ECONOMICS

1. THE ECONOMICS OF MARKETING HAY AND FEED GRAINS IN ARIZONA.

Project Number: 415 (WM-20). Funds: State, Hatch, Reg. Res.
Personnel: R. C. Angus.

The major work this year included compilation of lists of alfalfa growers in the Salt River Valley and Yuma areas of Arizona. A random sample of growers was selected. Half received the publication "Arizona Alfalfa Price Report." This report was written bi-weekly and sent to growers from May, 1960 to March, 1961. Interviews of recipients are planned after the hay from the 1960 season has been sold. These interviews are intended to evaluate the need for and usefulness of alfalfa market information.

The write-up of the hay quality-hay price study is underway. Preliminary results show little relationship between hay prices and U.S. grade factors.

An examination of feed grain storage is to get underway this year. This work will include an estimate of the storage capacity for grains as well as an investigation of the cost and profitability of storage.

2. EFFECTIVENESS OF PROGRAMS DESIGNED TO INCREASE THE CONSUMPTION OF DAIRY PRODUCTS.

Project Number: 442 (WM-36). Funds: State, Hatch, Reg. Res.
Personnel: J. S. Hillman.

The principal work has been devoted to the project with the American Dairy Association. The idea behind this work is to explore the possibility of introducing new fluid milk products to the market. Specifically, there seems to be a great possibility of introducing fortified fluid products, and products which will be lower in fat content but with a corresponding increase in percentage of nonfat solids. The following statement summarizes the work done this year, and supplements previous work.

The consumer preference study on milk beverages was extended to the homes of consumers in two separate tests--one involving 123 households at The University of Arizona and another involving 125 sample families in the city of Tucson.

As in prior consumer preference observations there was a significantly greater preference for the beverages with added SNF (solids nonfat). There was a slight preference for the low-fat beverage when compared with regular whole milk of the same total solids. There was a significantly greater preference for a low-fat beverage when compared with a nonfat product of practically the same total solids content. The preference indications of these observations are, in general, consistent with those found in earlier experiments. Preference differences (if any) seemed more pronounced which

might be due to the greater length of exposure to the products. The group tested on the city basis seemed to have a higher rejection for nonfat beverages than previous observations have indicated. Both groups listed a wide divergence of opinion in reasons for their preference.

The respondents were asked to indicate whether or not they were willing to pay a premium for a fortified milk, and their willingness was greater for the higher fat, fortified beverages.

Market tests have begun utilizing a fortified whole milk. This work will be continued and a final report will be written which will include market test results.

Two progress reports and one technical article for the Journal of Dairy Science have been published. Several popular accounts of the research have appeared in nontechnical publications.

3. APPRAISAL OF OPPORTUNITIES FOR ADJUSTING FARMING TO PROSPECTIVE MARKETS.

Project Number: 452. Funds: State, Hatch, and Reg. Res. Personnel: Aaron G. Nelson.

Primary effort during 1960 has been directed to obtaining additional basic data and to summarizing the data assembled. A few additional schedules were taken from farmers in early 1960 to complete the random sample referred to in the 1959 report. Price and cost data were obtained from appropriate sources to supplement the farm survey. These data included prices of insecticides and fertilizers, costs of various types of houses, buildings, and irrigation facilities; farm prices of gasoline, tractor fuel, butane, oil and grease; and rates for various types of property and liability insurance. With these data and those from the farm survey, input-output data were prepared as far as possible in physical and monetary terms and placed on punch cards to facilitate summarization and analysis. Tabulations are being prepared to aid in establishing typical farm situations for the five farm-size groups and to provide basic input-output data needed for analysis of returns from alternative systems of farming for each size group.

Work on tabulation and preparation of basic data will be continued. Additional data will be obtained from secondary sources as needed to supplement and/or round out the basic data for the project. Typical farm situations will be defined for the various farm-size groups and selected adjustments will be studied by use of budgets and/or linear programming.

4. TRANSPORTATION OF LIVESTOCK AND MEATS IN ARIZONA.

Project Number: 459 (WM-37). Funds: State, Hatch, Reg. Res. Personnel: R. E. Seltzer and Milton David.

This study deals with the economic problems associated with the transportation of livestock and meats within, from, and to Arizona. It has as its

objectives the development of a structure of transportation rates for these commodities, an appraisal of the rates, and an analysis of the influence of transportation rates on the location of livestock feeding and processing operations.

The analysis of livestock movements from specific origins to major destinations has been completed. The interviews with livestock truckers have been completed and data have been compiled from the schedules taken. Truck rates for the movement of Arizona livestock have been assembled and are being analyzed. Secondary data regarding the cost of operating livestock trucks have been developed and are being studied. Rates, services, volume of movement, and location are being correlated in an analysis of Arizona's structure of truck rates.

Arizona is cooperating with California in the development of an inter-regional transportation model designed to show the effects of transportation rates for livestock meat and feed on the location of livestock feeding and processing operations in the West.

The results of this study will be of use to livestock producers and processors in appraising the equity of the structure of livestock transportation rates, and in planning the location of feeding and processing facilities to minimize transportation costs.

During the coming year, the analysis of rates, facilities, and movements will be completed, and a manuscript will be prepared. Work on the inter-regional transportation model will be emphasized and a similar model, on a local basis, will be developed for Arizona.

5. EVALUATION OF THE EFFECT OF COMMERCIAL CATTLE FEEDING OPERATIONS ON METHODS OF SALE AND PRICE RECEIVED FOR SLAUGHTER CATTLE IN ARIZONA AND SOUTHERN CALIFORNIA.

Project Number: 460. Funds: State, Reg. Res., Hatch. Personnel: Thomas M. Stubblefield and Norman Gene Wright.

A larger portion of the total cattle marketed is sold direct to packers and feeders in the western part of the United States than any other area. More fat cattle are sold direct from the feedlot to packers in California and Arizona than anywhere else in the United States.

These cattle may be marketed through several alternative outlets. They may be sold direct to packers at the feedlot, through terminal stockyards, through local auctions, and they may also be sold on the packers rail, on a carcass grade and yield or on a consignment to packers.

Both proponents and opponents to each of these methods of sale are found among cattle feeders in Arizona. While no one method may be superior at all times and under all conditions, each method does have its unique advantages and disadvantages to the cattle feeder and to the packer. A thorough investigation of each of these methods of sale might lead to a more profitable choice of selling methods by cattle feeders in the West.

Analysis of the 1959 grade and yield and live weight sales was completed and a manuscript has been started. An analysis of live weight prices received for fat cattle sold in Phoenix, El Centro, Visalia, Los Angeles, and Denver markets was enlarged to include Kansas City and Omaha. In addition to the 1957 and 1958 data, 1959 data have been included and it is planned also to include 1960 data. A rough draft of this manuscript has also been made. The manuscript Marketing Cattle and Calves from Small Feedlots in Arizona and California has been approved for publication and will be published in early 1961.

It is expected that the manuscript on the sale of fat cattle on grade and yield as compared to live weight basis will be completed. The analysis of live weight prices at the "country" markets and the large central markets is also expected to be completed. A similar analysis of the prices received for stocker and feeder cattle and calves, or slaughter calves, at the "country" and large central markets will be started.

6. A STUDY OF ECONOMIC CONSEQUENCES OF CONTROLLING VELVET MESQUITE IN DESERT GRASSLANDS OF ARIZONA.

Project Number: 474 (W-16). Funds: State and Reg. Res. Personnel: Thomas M. Stubblefield.

The purpose of this study is to determine if it is economically feasible to remove the mesquite that is invading the desert grasslands of Arizona.

Data has been collected for the cost and time required for the removal of mesquite by chaining on six ranches. A total of 1,550 acres were cleared. Schedules are being taken to determine the cost of ranch operations in the southern part of Arizona.

Work to be completed in 1961 will determine the per cent of kill on the 1,550 acres of cleared mesquite and the cost of chemical control, if this information is available. A cost analysis of cattle production in southern Arizona is also planned. The expected increase in forage production will be estimated. The value of this increased production will be compared with the cost of the mesquite control.

7. INFLUENCE OF RECENT TECHNOLOGICAL DEVELOPMENTS ON THE MARKETING AND MARKET ACCEPTANCE OF ARIZONA COTTON.

Project Number: 490 (WM-41). Funds: Hatch and Reg. Res. Personnel: Lindon U. Cockroft.

The economies and diseconomies involved with a specific technological innovation, the development of portable baskets for transporting and temporary storage of seed cotton, are being investigated. Secondary data from previous seed cotton baskets and storage studies by the USDA at Clemson and Stoneville have been acquired.

A trip was made to the Wasco Gin Cooperative at Wasco, California. The purpose of this trip was to acquire data on a new system of seed cotton storage in ten-bale baskets in conjunction with the use of an unloading center. Photographs of the system were taken, along with an equipment inventory and cost, labor requirements, and rates of production.

It is planned that a comparative cost analysis report will be written covering various possible systems and their effects on unit cost of producing and ginning a bale of cotton.

8. THE COST OF OWNING AND OPERATING FARM POWER AND MACHINERY USED IN PREPARING LAND FOR PLANTING OF ARIZONA FIELD CROPS.

Project Number: 494 (W-62). Funds: Hatch and Reg. Res. Personnel: William E. Martin, Jim Armstrong (Agr. Econ.),Kenneth K. Barnes (Agr. Engineering).

A stratified random sample of farms in the four major agricultural counties was selected. Stratification was based on cropland acres. Ten schedules were taken in Pima County, 41 in Pinal County, 51 in Maricopa County, and 42 in Yuma County. Schedules record performance, repairs, depreciation, and other costs of owning and operating tractors and equipment used in heavy tillage operations, i.e., plowing and disking. Data from these schedules have been edited and prepared for two uses (1) transfer to IBM code sheets for use in the over-all analysis of regional project W-62, and (2) development of synthetic machinery use models for analysis of problems specific to Arizona.

Findings will provide (1) basic cost information on the using of agricultural machinery, (2) a basis for improved managerial decisions by farmers and their advisors, (3) a logical and consistent framework for machinery use decisions, and (4) new insights into the interrelationships involved in economical machinery use.

Twenty-five additional surveys will be taken. Data are being used to formulate machinery use models for alternative combinations of machinery, sizes of farms, and combinations of enterprises as a guide for efficient use of farm power.

9. DETERMINING AND SHARING COSTS AND BENEFITS FROM DEVELOPMENT OF THE CENTRAL ARIZONA WATERSHED.

Project Number: 495. Funds: State Research. Personnel: M. M. Kelso.

Work begun during 1959-60 on the importance of agricultural production in Central Arizona to the economy of Arizona and the consequent impact on Arizona's economy of declines or increases in that agricultural economy has been continued in 1960-61. Accomplishments during the current year have been wholly within the area of analytical, conceptual formulation of the problem and probable approaches to the study of it. To this end, progress has taken the form of extensive reading in the fields of economic development, spatial equilibrium,

and regional analysis, together with discussions of the problem with informed technicians and economic analysts.

A study was made for the Central Arizona project Committee of the "value of water for irrigation" on a typical farm in Central Arizona in 1960.

The usefulness of the findings so far are pretty much confined to the sound furtherance of the over-all objectives of the project. Continuation of the work described above is under way. It is planned to initiate at least one empirical study built upon the conceptual framework now being developed.

10. RETAILING MEATS AND MEAT PRODUCTS IN ARIZONA

Project Number: 496. Funds: Title II, State Research. Personnel: Raymond E. Seltzer and Thomas M. Stubblefield.

Over 1,500 retail grocery ads were coded relative to meat and meat items. This material is now being analyzed from IBM summaries. A detailed analysis of self-service meat displays in Tucson has been made. Data on weekly volume of meat sales, by type of meat, and advertised specials have been obtained and are being correlated with meat ads. Wholesale meat price series are being compiled and will be correlated with meat advertising programs to indicate the degree to which meat ads follow meat price trends.

It is anticipated that the study will be useful to retail meat dealers in evaluating the results of their newspaper meat advertising and the results of variations in display and other retailing practices.

Summarization of meat ads and display case data will be completed, and a statistical analysis of relationship between meat advertising and meat price trends will be made. Customers will be interviewed in stores relative to meat shopping habits.

11. PRODUCTION, PRICES, AND COSTS FOR ARIZONA FARM AND RANCH PRODUCTS.

Project Number: 497. Funds: State. Personnel: Raymond E. Seltzer and Staff, Department of Agricultural Economics.

This is a continuing project which has as its purpose the development of trends kn acreage, yield, production, and value of Arizona's principal crops, together with projected costs for the production of these crops. Livestock numbers, production, and value are also analyzed. An annual study is made of the supply-price-cost relationships for factors of production and crops and livestock produced. These relationships are reported in an annual bulletin, Arizona Agriculture 1961, the 31st in this series.

This work is widely used throughout the state. It provides a record of the progress of Arizona's agriculture and the crop budgets are used extensively by financing agencies. Ten thousand copies are printed. This project will continue along the same lines as in the past.

12. AN ECONOMIC EVALUATION OF THE IMPACT OF UNITED STATES AGRICULTURAL EXPORT PROGRAMS ON DOMESTIC AGRICULTURE AND AGRICULTURAL RELATED INDUSTRIES.

Project Number: 499 (IRM-1). Funds: State, Hatch, Reg. Res. Personnel: Jimmye S. Hillman and Douglas F. Loveday.

The Public Law 480 program has now been underway for sufficient time that the objectives and the results of its operation would bear critical analysis. Not only this; a thorough study should be made of the factors which led up to the inauguration of this program, as well as the attempts which the United States has made in the past to export its farm problem by government fiat. The area which would bear most analysis is that of the eco-political objectives of the current program. Is the program consistent with its stated objectives; is it being implemented in a fashion which will redound to the benefit of United States agriculture; is the program building a short-run and stop-gap structure which may impair the long-range security of the Free World? These and many other questions should form the basis of an analysis which would cover first, the field of surplus disposal, then the entire field of international agricultural trade problems.

Arizona began a project in this field in the 1959-60 fiscal year. Work on this project in the past year consisted of an appraisal of historical attempts to solve the farm problem through export disposal programs. One Master's thesis was completed on this historical aspect and another thesis is being completed on an analytical problem of evaluating the effects of PL 480.

In addition to the above, work has begun on specific commodity procedures, namely, wheat and cotton. This work is in its early stages and will necessitate considerable time for a complete analysis.

During the next year work will be completed on the historical analysis and a manuscript prepared on the entire progress of the project at Michigan and Arizona to date. Analyses of the specific impacts of the PL 480 on particular agricultural sectors will consume most of the time.

13. ALTERNATIVE PRACTICES AND SYSTEMS FOR INCREASED EFFICIENCY IN COTTON MARKETING.

Project Number: 512 (SM-24). Funds: Reg. Res. Personnel: Lindon U. Cockroft.

The committee has divided the project into three major areas--ginning phase, warehousing, and transportation. Subcommittees have been set up to develop the methodology and coordinate the work of each phase of the project. Arizona's representative is assigned to the warehousing and transportation subcommittee. Each member of the committee will assist in collecting data for all three phases of the work in his state.

Representative systems of marketing cotton in the Western Area of the Cotton Belt will necessitate a critical review of the warehousing and transportation practices that are currently widely accepted in the various areas.

This part of the study will be integrated with the ginning and merchandising phases being carried on at other institutions. Warehouse traffic sheets, published transportation rates, and current shipping routes will be obtained to determine the least cost transportation pattern and relative advantage between shipping points. These shipping patterns and proposed new patterns will be integrated with the newly developed gin complexes and merchandising systems. A survey of the existing cotton warehouses will be taken to obtain this information.

The results of this project should be of value to the cotton industry in adjusting to changes in processing and the organization and structure of cotton markets, which changes are now in process.

Work will be initiated along the lines specified in the statements of methodology for the three phases of the project. Arizona's specific responsibility in the project, warehousing and transportation, will be the initial contribution by this station. Data for the ginning and merchandising phases will be collected as required by those institutions concerned with the development of these phases.

Department of
AGRICULTURAL ENGINEERING

1. MECHANIZATION OF COTTON PRODUCTION AND HARVESTING.

Project Number: 269 (R.R. W-24). Funds: State, Hatch and Regional Research. Personnel: M. D. Cannon, K. K. Barnes, W. L. Kern, R. E. Smithson and K. C. Hamilton.

Tests included Cultivation and Cultural Practices, Harvesting, Residue Disposal and Crop Handling.

A significant increase in yield was indicated as a result of the application of Diuron prior to planting. The application of a layby herbicide, Telvar, also showed a significant increase in yield as compared to mechanical cultivation.

The use of hexadecyl alcohol as a spindle wetting agent in lieu of water had no effect on fiber quality, but it resulted in an eight percent loss in harvesting efficiency.

Additional tests with the Mitchell Stripper Harvester indicated that there is a loss in grade and a slight increase in nep count, when compared to a conventional spindle picker.

A new type stalk chopper, designed and built by the department, shows considerable promise in lower power requirement and ability to chop the stalks into finer pieces.

Fiberglas screen, used as a trailer cover and liner, seems to be advantageous from the standpoint of wearability and cost and is definitely effective in preventing the loss of cotton in transit from field to gin.

2. SPRINKLER IRRIGATION STUDIES UNDER ARID SOUTHWESTERN CONDITIONS.

Project Number: 303. Funds: Hatch and State Research. Personnel: K. R. Frost, K. K. Barnes, D. R. Rodney, L. Burkhart.

The permanent sprinkler irrigation system installed in young lemon trees on the Yuma-Mesa was in operation for the third year. Water applications were increased to provide for larger trees. A total of 10.9 acre-feet per acre was applied to the flooded plots and 5.5 acre-feet per acre to the sprinkled area during the 12-month period. The tree girth measurements show 18.6% greater increase in growth for the sprinkled trees than for the flooded.

During the spring months a sprinkler system was used to irrigate grain. The treatments were frequent, regular night, and regular day sprinkling and flood irrigation. The yields were the highest on the frequent sprinkled followed by night sprinkled, then flooded and daytime sprinkling. Comparisons in tons per ac.ft. of water are shown in the table.

Comparative Yields and Water Application

	Night	Day	Flooded	Freq.
Total in. applied (incl.rain)	12.50	12.65	19.50	12.80
Yield in Tons/Acre	3.70	3.18	3.54	4.05
Tons per Ac. Ft.	3.52	3.02	2.20	3.80

The same treatments were used on A-44 Cotton during the summer. Yields from the night sprinkled (3015#) equalled the furrow irrigated plots (2980#) in seed cotton per acre though other sprinkled treatments were somewhat less, (2740#) for the daytime sprinkled and (2560#) for the frequent sprinkled. The pounds of seed cotton acre-feet of water were: Night sprinkled 623; daytime sprinkled 600; frequent sprinkled 713; and furrow 543.

3. HYDROLOGY AND WATER UTILIZATION OF SMALL SEMI-DESERT DRAINAGE AREAS.

Project Number: 375. Funds: Hatch, State, Regional Research.
Personnel: D. W. Fonken, H. C. Schwalen, W. L. Kern, W. G. Matlock, Sol Resnick.

OPERATIONS:

Precipitation and runoff measurements were continued on the Atterbury Watershed including the dense network of raingages. Recharge investigations were continued using basins constructed adjacent to Atterbury Dam. A study was made to relate land pan evaporation to evaporation from a standard raingage during the summer months. The mean error in gage readings caused by evaporation was found to be 2.6% of the land pan evaporation for the period. With the addition of more data the depth-areal relationship for summer convectional thunderstorms in this area was recomputed and found to be changed from that computed previously. More years of data collection will be needed before this relationship approaches a constant value.

RAINFALL ANALYSIS:

In the calendar year 1960 annual point precipitation varied from 10.43 inches to 6.44 inches. Mean annual precipitation for the watershed was 8.96 inches which is 83% of the 67-year mean at The University of Arizona Station. The addition of the dense raingage network has demonstrated the inadequacy of a 1-mile network for gaging thunderstorm rainfall.

RUNOFF ANALYSIS:

Total runoff for the year was 215 acre-feet which is only 2.56% of the mean annual precipitation. There were 44 storm periods in 1960; however, 90% of the runoff was produced by only three of these storms.

4. THE PRODUCTION AND UTILIZATION OF TAMARISK (TAMARIX ARTICULATA).

Project Number: 400. Funds: State. Personnel: K. R. Frost, K. K. Barnes.

Of the fifty tamarisk posts treated green and dry and set on the Page Ranch (dry desert) near Oracle Junction, most of them remain solid after 18 years except the wood-tar creosote treated. Four failures occurred this year - 2 coal-tar treated dry, 1 wood-tar treated dry and 1 zinc chloride treated green. Failures to date are: 5 green and 7 dry treated with wood-tar creosote, 1 dry and 1 green treated with pentachlorophenol, 2 green and 4 dry treated with coal-tar creosote and 1 green treated with zinc chloride. Eight of each treatment were placed in the ground in 1942 except for the 2 only zinc chloride treated. All untreated posts have failed. Of a similar setting of posts on the irrigated Campbell Avenue Experiment Farm, all had failed by 1957.

Fence posts set in the fence line at the Kinne Ranch southwest of Coolidge, Arizona and treated dry and green with coal-tar creosote had one failure this year. Total failures to date are 37 treated green and 35 treated dry, of the 140 tamarisk posts at this location.

5. GROUND WATER SUPPLIES.

Project Number: 436. Funds: State and Other. Personnel: H. C. Schwalen and R. J. Shaw.

Upper Santa Cruz Valley

Water level measurements in Santa Cruz County indicated no material change in the water table between the Spring of 1959 and 1960 as far south as Otero Station. South of Otero as far as Calabasas water levels were up to approximately the streambed of the Santa Cruz River and in a few places the groundwater appeared as surface flow in the channel. Water levels reached their highest elevation since measurements were started since 1940. The irrigated acreage in Santa Cruz County according to the crop survey in 1960 was 5100 acres, using approximately 17,500 acre-feet.

Sahuarita - Continental Area.

Maximum recovery of as much as 5 feet took place in the south end of the area near the Santa Cruz County line. In the vicinity of Sahuarita recovery was evident in a strip along the Santa Cruz River with losses of approximately 3 feet in a band on both sides further out and paralleling the river. Recovery was due primarily to winter floods of 1959-60.

Tucson Area.

The usual decline in the water table in the central portion of the area occurred with the maximum losses of 5 feet occurring southeast of the City along 22nd Street between Alvernon and Kolb Roads between 1959 and 1960. The 13-year depression occurs in this same general area.

The winter flood flows of 1959-60 provided exceptional recharge possibilities in the Rillito Creek bottom land with recovery of as much as 27 feet in a few wells. Residual volumetric recharge amounted to 12,100 acre-feet and actual recharge considering losses to phreatophytes and pumping for irrigation and domestic use must have been at least 21,000 acre-feet during a period March 1959 to March 1960.

Cortero Area.

In this area recharge from flood flow in the Santa Cruz River plus deep percolation losses from the use of sewage water for irrigation combined to give recovery of as much as 5 feet in the bottom land. Likewise in the upper Canada del Oro region spectacular rises of as much as 45 feet were observed, however, on the valley slopes in areas where direct recharge does not occur the usual losses of between 1 and 2 feet took place.

Avra-Marana Area.

The north end of this acreage where the most concentrated pumping takes place was subject to the usual loss in water levels of about 6 feet per year. Noticeable in the west end of the area near Picacho Peak was the development of parched water tables with water cascading from upper to lower strata in wells with marked lowering of the water levels in the lower strata. The original uniformity in character of the groundwater contours has been disturbed and in some areas it is doubtful if equilibrium in the water table is accomplished by the time Spring measurements are made.

In the south end of the area near Ryan Field and Three-Points the irrigation draft has not increased in the last few years and little lowering since the initial drop in water levels has taken place.

In the area between Three-Points and Ryan Field water levels drop about 140 feet in about 2 miles. To date there is no acceptable explanation for this groundwater fall and the logs of the few wells in the area have offered no clue. This is within the area selected by the City of Tucson for expansion of the Municipal supply and it is hoped some geophysical testing may be conducted in this area during the coming year.

Little Chino Valley

Water levels and artesian pressures have lowered progressively throughout the artesian basin since studies were initiated in 1938. The cumulative loss has amounted to almost 40 feet, uniformly over the basin. The artesian waters are extremely sensitive to pumping draft and during the summer pumping season the pressures and water levels drop about 30 feet with subsequent recovery by the next Spring to within 1 or 2 feet of their previous levels.

There has been little change in irrigation draft over several years. Crop surveys for 1959 and 1960 showed the irrigated acreages from groundwater were 3630 and 3620 acres respectively with estimated water requirements of about 12,700 acre-feet. The City of Prescott's pumpage from the same basin for municipal use was 1600 acre-feet in 1959 and 1690 acre-feet in 1960.

6. DESIGN OF SEWAGE DISPOSAL SYSTEM FOR DAIRY WASTES.

Funds: State Research. Personnel: F. Wiersma.

Dairy cattle wastes and washdown from the milking parlor, holding pen and milk tank room were run into a 10,000 gallon underground concrete tank, and from there through a liquid flow measuring device to a city main.

Breakdown of solids was inadequate, indicating that anaerobic bacteria are incapable of complete reduction of solid materials from dairy wastes. Reduction of the wastes to liquid form will require in addition to anaerobic attack, additional treatment such as mechanical removal of fines or attack by aerobic bacteria or both.

Average liquid flow of wastes and washdown averaged about 2.5 cubic feet per cow milked per day which was 0.5 cu.ft. less than the estimated flow used for design calculations.

7. SORGHUM PRODUCTION AS RELATED TO PLANT SPACING AND IRRIGATION SCHEDULE.

Funds: State (Agr. Engr.), Hatch (Plant Breeding). Personnel: F. Wiersma (Agr. Engr.), Lee Stith (Plant Breeding).

RS 610 Sorghum was planted for the third season at Marana Farm using two different row spacings, 40-inch and 20-inch with two seed spacings in the 20-inch rows. The cloddy condition of the soil required an additional pre-irrigation and tillage, making an early planting for double harvesting impossible. All plots were planted with a lettuce bedder and harvested only once.

Fields in the 20-inch rows were about 25% greater than in the 40-inch rows, a result similar to those of the previous years. However, unlike earlier results, the heavier populations in the narrow rows yielded about 12% greater than thinner plantings of the same row width.

Maintaining high moisture levels throughout maturity increased yields significantly. However, this was at least partially the result of a re-growth crop in the high moisture plots which, because of favorable weather conditions, reached maturity and was harvested with the initial growth.

8. EFFECT OF LENGTH OF SERVICE AND CHANGING OPERATING CONDITIONS UPON THE FIELD EFFICIENCY OF DEEP WELL TURBINE PUMPING PLANTS.

Funds: J. G. Boswell Co. Personnel: H. C. Schwalen, W. G. Matlock.

The data from 1959 tests were analyzed and results summarized in a thesis, "A Comparison of Field Performance with Design Characteristics of Deepwell Centrifugal Turbine Pumps." The thesis is on file in the Library, The University of Arizona, Tucson, and in the Agricultural Engineering Department.

Another series of field tests was made on the same pumps in August, 1960, for comparison with previous test results.

Preliminary investigations were made to determine an adequate method for sampling the sand content of pumped water.

Computations and analysis of the test data show little possibility of directly correlating the results from different pumps because of the effect of variables in the pump installations. Test results show that pump efficiency is directly related to length of service, but the sand content of the pumped water appears to be the controlling factor.

Department of
AGRONOMY

1. WEED CONTROL ON IRRIGATED LANDS.

Project Number: 261. Funds: Hatch. Personnel: K. C. Hamilton, (H. F. Arle and G. N. McRae, ARS Collaborators), K. R. Frost, Jr., G. D. Massey, R. K. Thompson.

Cotton - Pre-plant applications of diuron gave several months control of annual weeds with no effect on yield or fiber quality in irrigated cotton planted in moist soil. Diuron is applied to the soil before furrowing for the pre-planting irrigation at rated dependent on soil type. A hazard of pre-planting applications is the herbicide may reduce stands if rainfall occurs when plants are 1 to 2 inches high. Layby applications of combinations of herbicides continued promising.

Corn - Pre-plant applications of simazin stunted corn and reduced yields. Atrazine gave excellent weed control in corn.

Small Grain - Low rates of barbane controlled wild oats with little effect on barley and wheat.

Sorghum - Pre-emergence application of casoron, ducthal, diuron and zytron controlled annual grasses in plantings on beds that were irrigated up.

Soil Residues - Two ounces per acre of urea herbicides in the soil sometimes reduced small grain stands and yields. Soil residues have affected the first crop, the second crop if broadleaved, and had no effect on the third crop planted after spot applications of 2, 3, 6-TBA.

Perennial Weeds - Under field conditions regrowth of individual Johnsongrass plants after treatment with dalapon has occurred primarily from rhizomes about to emerge when the herbicide was applied.

2. COTTON PRODUCTION UNDER IRRIGATION.

Project Number: 264. Funds: Hatch. Personnel: R. E. Briggs, L. L. Patterson, Jeane Millane

In the study of cotton boll set, the process of fertilization appeared to be necessary for boll growth following a 72-hour period after anthesis. Auxin concentrations of normal bolls of different ages in hours after anthesis were highest at 48 hours, dropped sharply at 72 hours and started to increase again at 96 hours.

Foliar applications of Gibberellic acid (GA) did not significantly increase yield for the third consecutive year. The potassium salt and butyl cellosolve ester of GA were tested. Percentage boll abscission was reduced by GA treatment but boll size was also reduced.

For the second straight year, cotton yield was significantly higher and Verticillium wilt symptoms were less where cotton was grown after a year of fallow compared to cotton grown following cotton.

Delta Pine Smoothleaf significantly outyielded five Acala varieties where "Crazy Top" was severe.

In an irrigation-fertilization-variety experiment at Yuma, boll size and the Micronaire reading increased with an increase in the number of irrigations. The irrigation-fertilization interactions were also significant for boll size and the Micronaire reading. Spinning results from this test for strength of 22's yarns averaged 135.0 for Acala 44-10 and 114.4 for Delta Pine Smoothleaf.

Fertilizer treatment did not influence any of the boll or fiber properties in a date of planting-variety-fertilizer test at the Cotton Research Center.

The variety Wescot continued to yield well at all locations where tested. Wescot yielded higher than all other varieties at Marana under Verticillium wilt conditions. The rainbelt varieties grown at Marana were all quite susceptible to Verticillium wilt.

3. SEED PRODUCTION OF FORAGE PLANTS.

Project Number: 304. Funds: Hatch. Personnel: N. Wright, E. Jackson, A. A. Baltensperger, L. P. Hamilton.

Final results of a 2-year study of the effect of insecticide treatments on seed-set, seed yield, seed quality, and insect population of black gramagrass were obtained in 1960. The effect of insecticide treatments on seed-set were nonsignificant. Seed yields were nonsignificant for insecticide treatments one year and significant the other. Wide differences were found between years for seed yield. A satisfactory method to process small quantities of black gramagrass seed has not been developed which largely accounts for the between year differences; however, processing within years was consistent so it is felt that treatment effects are acceptable. Insecticides did not control any particular group of insects, so there was no apparent insecticide selectivity as to class of insect. There could be temporary control with possible insect life cycle interaction. Germination percentages as a measure of seed quality were nonsignificant for treatments while there was a highly significant difference between years with the older seed the poorest.

Seed quality determinations of black gramagrass were completed relative to the effect of dates, pre-treatments and fertilizers. Seed weight showed a highly significant increase when growth was initiated on Aug. 15 rather than Aug. 1 for the first year while dates were nonsignificant the second year. This response was directly related to seed yield data. Germination percentages were significantly higher for the early date of turning to seed for both years. Other treatments were nonsignificant for seed weight and germination.

The first year's data from the blue panicgrass seed-set, seed quality and seed yield indicates a progressive increase in seed yield with increased

nitrogen. Considerable shattering was noted in the lower nitrogen plots. Seed yields were lower for the wet treatment at the lower nitrogen levels; however, at the higher nitrogen levels the reverse was found.

The bermudagrass seed study required half of the growing season to become established. Treatments were applied for the fall harvest which has not been processed.

4. THE IMPROVEMENT AND CULTURE OF SMALL GRAINS.

Project Number: 305. Funds: Hatch. Personnel: A. D. Day, R. T. Ramage, R. K. Thompson, G. D. Massey, T. C. Tucker, and M. G. Vavich.

Variety yield tests for barley, oats, and wheat were grown at 3 locations in Arizona: Yuma, Mesa, and Safford. The yield test data were summarized in a ditto report (Day, A. D., Thompson, R. K., and Massey, G. D. 1960 progress report on small grains variety tests. Arizona Agr. Exp. Sta., Ditto Report No. 1, 15 p. September, 1960). Arivat and Blanco Mariout barley, Palestine and Curt oats, and Gabo and Yaktana 54A wheat were high yielding grain varieties. Data were obtained from the yield tests at Yuma and Mesa to study the following points in addition to grain yield: (1) border effect; (2) correlation between total grain yield and the grain yield estimated using the three yield components (a) number of heads per unit area, (b) number of seeds per head, (c) weight per 1,000 seeds; and (3) correlation between total grain yield using normal size plots (12 feet long) and total grain yield using 6-inch plots.

Four experiments conducted over a three-year period (1955-57) at Mesa to study the use of oats for winter forage in Arizona were completed and summarized in an article in Progressive Agriculture in Arizona (Thompson, R. K., and Day, A. D. Oats for winter forage in Arizona. Progressive Agriculture in Arizona 12(3):4. Fall, 1960). Markton was the most desirable oat variety for winter pasture, green-chopped feed, and hay.

Six experiments conducted over a two-year period (1957-58) to study the hay production of small grains irrigated with sewage effluent were summarized and reported in a paper in the Agronomy Journal (Day, A. D., and Tucker, T. C. Hay production of small grains utilizing city sewage effluent. Agronomy Journal 52:238-239. April, 1960.) Barley, oats, and wheat utilized sewage effluent efficiently in the production of hay. Barley appeared to be more sensitive to the undesirable effects of sewage effluent than oats and wheat.

Four greenhouse experiments conducted in 1958 to study the residual effect of 1,2,3,5-Tetrachlorobenzene (TCB) on the germination and seedling vigor of barley, oats, and wheat in four different soil types were summarized and reported in the Agronomy Journal (Ameen, O. A., Day, A. D., and Hamilton, K. C. Effect of 1,2,4,5-Tetrachlorobenzene on the germination and seedling vigor of barley, oats, and wheat. Agronomy Journal 52:87-89. February, 1960.) The detrimental effects of TCB were most serious in sandy soil. As the soil type changed from sand, to sandy loam and clay loam, to clay, the damage produced by TCB decreased. Injury to small grains did not occur when planting was 125 days after soil treatment with up to 135 pounds of TCB per acre.

An experiment initiated in 1959 to compare visual selection versus random selection as methods of making high yielding F_6 selections from barley populations was continued at Tucson.

Breeding nurseries were grown at Tucson and Mesa in an attempt to incorporate some of the desirable characteristics of unadapted varieties into the recommended Arizona varieties.

5. ALFALFA IMPROVEMENT.

Project Number: 341. Funds: State Research. Personnel: M. H. Schonhorst, R. K. Thompson, K. Frost, Jr., A. R. Kemmerer.

Two years' data from a test comparing the effect of summer irrigation vs. summer dormancy on border-size plots of Moapa alfalfa can be summarized as follows: (1) Average forage yield over three rates of planting (15, 20, 25 lbs. seed/acre) for the summer dormant plots was 16,849 lbs. hay per acre, for the summer irrigated plots 18,481 lbs. per acre. This average increase of 1632 lbs. per acre required two additional irrigations per season. However, plant populations thinned more under irrigation than where summer dormancy was imposed.

A border-size plot of Moapa alfalfa was successfully established on the Safford Farm using well water high in salt content (approx. 5,000 lbs. salt/acre ft. of water). Timing of water application appeared to be very critical in stand establishment. A limited amount of seed was obtained in the fall of 1960, therefore, a second harvest will be made in mid-summer of 1961.

An analysis of data from the polycross progeny test on the Safford Farm indicated an exceptionally large coefficient of variation (26%), therefore, production tests were discontinued.

6. THE EFFECT OF LENGTH OF DAY AND CULTURAL METHODS ON THE REPRODUCTIVE POTENTIAL OF ALFALFA.

Project Number 367 (W-58). Funds: Hatch. Personnel: M. A. Massengale, D. F. McAlister, F. E. Todd and C. O. Stanberry.

Studies of the response of African and Vernal alfalfas to two different photoperiods under field conditions was continued in 1960. Alfalfa plants were exposed to the light treatments during two growth periods (May through July and August through October). Response of plants to the light treatments was evaluated by data obtained on the number of days from cutting to the appearance of the first flower, height of plants, dry weight, and seed weight per plant. The number of days from cutting to appearance of the first flower was the most sensitive to photoperiod, and this response was greater during the second growth period than the first. The influence of photoperiod on seed production was also more pronounced during the second growth period. Generally, short photoperiods tended to increase vegetative growth.

An experiment was initiated in 1960 to study the effect of genotype, plant spacing, growth regulators and boron on vegetative growth, flowering,

sugar content of the nectar, dry weight of the plants, and yield of seed of alfalfa. Plants that were sprayed with 40 and 80 grams of 2,4,5-T per acre showed curling and bending of the topmost internodes a few hours after spraying, flowers that were open at the time of spraying turned brown, and sugar content of the nectar was decreased. Plants spaced 24 inches apart in the row produced more nectar sugar than plants spaced 6 inches apart, and in general sugar content of the nectar tended to decrease as the plants progressed with seed setting.

There was a significant difference in seed production among clones, and plants spaced 24 inches apart in the row produced significantly more seed than those spaced 6 inches apart.

A cooperative experiment with personnel of the Wyoming Agricultural Experiment Station was conducted to evaluate the effect of two diverse environments on vegetative growth, flowering, sugar content of the nectar, seed production and the response of a selected genotype to growth regulators. Data from the Tucson portion of the experiment indicated that spraying with 2,4,5-T when plants were in the late bud and one-third bloom stages of growth decreased the sugar content of the nectar. However, seed production was increased when plants were sprayed with Duraset 20W in the late bud stage of growth and 2,4,5-T in the one-third bloom. The occurrence of two killing frosts in midsummer at Laramie prevented obtaining data at that location.

7. INFLUENCE OF CLIMATIC FACTORS ON FIBER PROPERTIES IN COTTON.

Project Number: 380. Funds: Hatch. Personnel: R. E. Briggs, Jeane Millane, Doris Waterworth.

Fiber quality data from samples collected at various gins in southern Arizona are being processed for analysis. Correlation coefficients of the various fiber and seed properties were determined from ten-day averages between any two of the first three years. The fiber properties length (both the upper half mean and the mean length) and strength had very few significant correlations at any period throughout the season. For the ten-day periods between October 1 and December 1 there were numerous correlations for the other factors tested; namely, fineness, percent lint, lint index and seed index. Correlations were highest with the factors fineness and percent lint.

Over 4,000 lint samples were collected from the 1960 cotton crop from gins located at elevations of approximately 1,100 feet to 2,600 feet. Samples were collected throughout the harvest season. These samples are being used to compare fiber length as determined by the Fibrograph with the length determined in the Classing Office. The samples which are Acala 44 will also be tested for strength, fineness and maturity.

8. THE IMPROVEMENT AND CULTURE OF CORN.

Project Number: 394. Funds: State Research. Personnel: A. D. Day, R. K. Thompson, G. D. Massey.

Since 1956, the following corns have been collected and added to the Arizona Corn Collection:

1. Three commercial strains of Mexican June.
2. Four Arizona strains of Mexican June.
3. Sixteen Indian corns from the Arizona State Fair, Chino Valley in Arizona, and Tucson grocery stores.
4. Twenty-three Arizona Indian corns and one corn color bulk obtained from R. T. Ramage.

In 1960, the strains of Mexican June, the Indian, and the corns obtained from R. T. Ramage were grown at Tucson and a number of crosses were made between different plants within each population (or "strain") to produce seeds that would be representative of each individual strain. At maturity, the seeds obtained from the sib-pollinations between plants within each population were harvested, shelled, bulked, cleaned, and stored for future use.

In 1960, a corn composite cross was produced at Mesa by permitting cross-pollination to take place between a bulk planting made up of a mixture of seven strains of Mexican June as the female parent and a bulk planting made up of a mixture of sixteen different Indian corns from Arizona and Ramage's Corn Color Bulk as the male parent. The seeds produced on the female plants were harvested, shelled, and bulked to produce Arizona Corn Composite Cross I (ACCCI). The seeds of ACCCI were then placed in storage for future use.

9. PRODUCTION AND IMPROVEMENT OF NEW CROPS FOR ARIZONA.

Project Nmmber: 401. Funds: Hatch. Personnel: D. D. Rubis, R. K. Thompson, K. R. Frost, Jr.; and D. S. Black, L. H. Zimmerman, and W. Bailey, USDA Collaborators.

In safflower a method has been devised for evaluating both seed-set ability and yielding ability of thin-hull breeding material when grown in a nursery isolated from normal-hull safflower. By the use of this method seed-set ability was determined for over 3000 individual plants in 1960; and pure thin-hull selections were first tested in yield tests at several locations. Results show that breeding procedures used for increasing seed-set have been effective, but that existing thin-hull lines are lower in yielding ability than normal-hull lines. Several new genetic mutations in safflower have been isolated and one, a second-bloom characteristic, may be valuable in increasing yield in safflower.

In both the soybean and peanut projects new lines with higher yielding ability and improved performance have been increased for field testing and possible future release.

In the flax project a number of wild species were shown to have Curly Top resistance.

In castor beans a method has been developed for producing selfed seed on homozygous (ff) pistillate plants in the Yuma area. This seed planted at Tucson and Davis, California, produced all pistillate plants in the next generation.

10. CULTURE AND WATER ECONOMY OF SOIL IMPROVING CROPS.

Project Number: 402. Funds: Hatch. Personnel: D. D. Rubis, R. K. Thompson, G. D. Massey and L. N. Wright.

The experiment on production and survival of several grass species and Moapa alfalfa under limited irrigation was continued at Mesa. In 1960 the Moapa alfalfa maintained stands and produced about three times the amount of forage of any of the grasses under all three levels of irrigation. The side oats grama and Turkestan bluestem produced the least under all three irrigation levels; however, the bluestem was very favorable from the standpoint of spread and survival. The Boer lovegrass, blue panicum, and Panicum coloratum produced the most forage among the grasses. The species P. coloratum continues to be the most favorable grass species when both ground spread and forage production are taken into consideration.

In 1960 the production and survival experiment at Yuma was discontinued without any conclusive evidence available. The location proved to be undesirable because of a relatively high water table and because of root rot in the soil. The stands of African alfalfa were poor due to both root rot and aphid injury.

11. THE EFFECT OF TEMPERATURE AND DAYLENGTH ON GROWTH AND DORMANCY IN ALFALFA.

Project Number: 468. Funds: Hatch. Personnel: M. A. Massengale, H. A. Brubaker and D. F. McAlister.

Detailed observations were continued on the twelve varieties of alfalfa that were seeded in 1959 and have been grown under long- and short-day photoperiods. Short-day photoperiod consists of natural daylength and long-day photoperiod consists of natural daylength plus an interruption of the dark period for 20 minutes in the middle of the night.

Ninety percent of the plants of all varieties flowered more quickly in the spring and the first cutting was made earlier under long days than short days. Total number of harvests was more under long days for all varieties except Caliverde which was harvested the same number of times under both daylengths. Generally the nonwinter hardy and intermediate winter hardy varieties produced more total dry matter under short days, and the very winter hardy varieties produced more total dry matter under long days.

Measurement of the diameters of plant crowns revealed that the crowns of plants growing under short days were significantly larger than those growing under long days.

Classification of all plants was made in early February as to their dormancy and type of growth. This classification showed that the ratio of nondormant to dormant plants was higher under long days than short. Also a higher percent of the nondormant plants grew more erectly under long days whereas short days tended to favor a prostrate or semi-erect type of growth.

An alfalfa management study revealed that cutting consistently at the early to mid-bud and early bloom stages of growth reduced the total yield of forage and seriously reduced stands during late summer of the second harvest year when compared with cutting at the full bloom stage. Differences between the ratio of leaves to stems was evident among all stages of growth. The highest percentage of leaves were present at the earlier stages and lowest at the more mature stages.

12. IMPROVEMENT OF ALFALFA BY BREEDING FOR INSECT AND DISEASE RESISTANCE.

Project Number: 473. Funds: Hatch. Personnel: M. H. Schonhorst, P. D. Keener and M. W. Nielson.

A nine-clone experimental alfalfa synthetic was developed based on general combining ability tests with progeny grown in wide-spaced, single-row plots. A second experimental 13-clone synthetic was developed based on general combining ability tests with progeny grown in closely-spaced, multiple row plots. Seed of each of the two synthetics plus their components was planted in closely-spaced, multiple-row plots for tests of forage production, insect reaction and stand persistence.

Ten 2-clone combinations were established to compare production in single-cross combinations with that of polycross progeny performance.

Several 2-clone hybrid combinations were established and yield tested in 1960. The hybrid consisting of two high-combining lines out-produced combinations in which only one, or none, of the parents was high in general combining ability.

Further tests on the spotted-aphid resistant cones selected from the introduction, Sirsa, indicate that this material is less winter dormant and less susceptible to lodging than the African selections tested thus far. One Sirsa plant has been found which has resistance to three insects, the spotted alfalfa aphid, pea aphid and clover seed chalcid. This is the first known case of clover seed chalcid resistance in alfalfa.

Twenty-four Chilean Alfalfa plants were obtained from an 8-year-old field near Arlington, Arizona. These plants were free of spotted aphids and honeydew while other plants in the field were heavily infested. Vegetative cuttings of each clone were established on the Mesa Farm for antibiosis testing. An isolated polycross nursery was established at Tucson for seed production. This seed will be used for progeny testing of the parent lines.

Plantings of polycross progeny of spotted aphid resistant African and Lahontan clones were established in an area heavily infested with crown and root rots on the Mesa Farm. Approximately one-half of the populations were

killed during the first season. Additional thinning of stands is expected in 1961.

Forage production of inter-variety crosses exceeded production of intra-variety crosses, indicating possibilities of obtaining heterosis in alfalfa combinations.

13. THE GENETICS OF RESISTANCE TO THE SPOTTED ALFALFA APHID.

Project Number: 477 (W-40). Funds: State Research. Personnel: M. H. Schonhorst, W. H. Powell (Grad. Student) and M. W. Nielson.

Crosses were made between tetraploids with various levels of resistance to the spotted alfalfa aphid. Seedlings were established in the greenhouse and transplanted to the field for antibiosis tests.

Medicago sativa and M. falcata populations were established in the greenhouse and antibiosis tests initiated. Preliminary results indicate that aphid reproduction on diploids varies considerably from plant to plant. Plants with very low levels of aphid reproduction have been found.

Clones, S_1s and F_1s of three pea aphid resistant plants reported in 1960 have been produced and have been included in the aphid tests.

14. BERMUDAGRASS IMPROVEMENT.

Project Number: 502. Funds: State Research and 2RC Bermudagrass. Personnel: A. A. Baltensperger and Neal Wright.

The wide source of bermudagrass material collected during 1959 was established in replicated field plantings. Data were collected during 1960 on these individual plants and large phenotypic differences were found for many attributes. Additional data will be collected on this experiment in order to estimate genotypic variation and heritability, which should be useful in determining the most effective breeding procedures for bermudagrass.

A preliminary study of the pollination cycle of bermudagrass indicated the time of anthesis to be from about 8:00 to 9:00 p.m. This experiment will be repeated to study the effect of season of year and species on the pollination cycle.

Turf and forage strain evaluation experiments indicated a wide range of adaptation to Arizona conditions. Variety and strain differences in regard to disease and insects resistance were also noted.

15. FIELD CROPS RESEARCH IN NORTHERN ARIZONA.

Project Number: 503. Funds: State Research. Personnel: M. A. Massengale, T. C. Tucker, R. L. Voigt, R. E. Dennis, Alvin Allen and A. H. Underwood.

Studies on the seedling establishment of alfalfa were continued for the second year. Similar data were collected in both 1959 and 1960. Ranger and Lahontan alfalfas were seeded alone and with oats as a companion crop on April 18, 1960. Oats were overseeded at rates of 25, 50, 75, 100 and 125 pounds per acre.

Stand counts of the number of alfalfa plants were made approximately three months after seeding. These counts revealed that significantly more plants were obtained when alfalfa was seeded alone than when seeded with a companion crop. Yield data showed that there was no difference in the amount of forage obtained from the oats when weeded at the different rates. However, similar data for one harvest of alfalfa indicated that plants seeded alone produced significantly more forage than plants seeded with oats at the higher rates.

Oats provided more competition with the alfalfa plants in 1960 than 1959. Seedings were stressed more for water in 1960, and under these conditions oats seeded at the heavier rates hindered development of the young alfalfa plants.

Data obtained in 1960 from the experiment established in 1959 showed that there was no difference during the year following seeding in the number of plants or yield whether the alfalfa was seeded alone or with a companion crop.

The cooperative experiment with Dr. T. C. Tucker on timothy fertilization was continued. Nitrogen fertilization significantly increased the height of plants and yield of forage. There was no response to phosphorus.

A barley variety test in Chino Valley indicated that Arivat and Harlan were similar in total production. Both varieties were considerably higher yielding than Vaughn.

A cooperative experiment was conducted with Drs. T. C. Tucker and R. L. Voigt on variety and fertilizer tests with corn and sorghum for silage at Snowflake. Corn produced more silage than sorghum and Pfister 485 was the highest yielding corn variety for the second year. Corn showed a greater response to nitrogen fertilization than sorghum. Neither crop consistently responded to the application of phosphorus.

16. CROPS RESEARCH IN THE WELLTON-MOHAWK VALLEY.

Project Number: 506. Funds: State Research. Personnel: E. B. Jackson.

When compared under different levels of moisture and nitrogen fertility, first picking yields of D.P.L. Smoothleaf and Acala 44-10 cotton increased as the frequency of irrigation was increased. However, this increase was greater for the D.P.L. than for the A-44-10. In the second picking, more frequent irrigations were beneficial only at the highest level of nitrogen. Yields were generally higher from the A-44-10. Total yields showed no overall benefit from nitoogen, but were higher for the highest moisture level. For any given irrigation or fertilizer treatment, the yield from Delta Pine was greater than from the Acala variety. Neither fertilizer nor irrigation

schedules had any effect on storm losses. However, the losses from Delta Pine were consistently higher than from the Acala.

Neither varied irrigation schedules nor different rates of nitrogen fertilization resulted in differences in yield of Acala 44 seed cotton in the North Gila Valley.

In the Dome Valley, "wet" and "medium" irrigations were approximately equal in their effects on yield of cotton in D.P.L. Smoothleaf and A-44. "Dry" irrigations reduced yields in both varieties. Yields were unaffected in both varieties by nitrogen rates to 240 pounds per acre and P_2O_5 at 100 pounds per acre.

A-44-10 was the high yielding variety in a test which included D.P.L. Smoothleaf, Wescot, Stardel, Acala 4-42 and 44-WR at Roll.

Gila safflower planted at different rates in solid stands and in rows 30" apart, demonstrated the ability to compensate for thinner stands in producing yield of seed. Higher yields were obtained from solid stands than from 30" rows both at Wellton and Yuma. One hundred pounds of nitrogen per acre applied in two applications of 50 pounds each was better than either 50 or 100 pounds applied at planting time, and equal to 200 pounds applied in a split application. At both locations, the oil content of the seed decreased as the rate of nitrogen fertilization was increased.

Department of
ANIMAL PATHOLOGY

1. RANGE LIVESTOCK LOSSES FROM POISONOUS PLANTS.

Project Number: 171. Funds: Hatch and State Research. Personnel: W. J. Pistor, R. E. Reed, Robert Trautman, R. H. Diven, C. T. Mason, Jr.

Two hundred and seventy-one randomly selected plant samples representing 33 plant species were analyzed for nitrate concentration. The percentage potassium nitrate varied among species from 0 to 25%. Only three species were completely devoid of nitrate.

Forty-seven samples of six varieties of Bermudagrass were analyzed for nitrates. The varieties tested included: Common, Giant (NK-37), Coastal, Star grass and Midland. Fertilization ranged from 0 to 2400 pounds of nitrogen. Potassium nitrate values ranged from 0.55% to 1.10%.

One hundred samples of blue panic grass were analyzed for potassium nitrate in an attempt to select out low nitrate accumulators. No nitrogen had been applied. The mean was 0.26% nitrate. Values ranged from 0.0% to 0.90% nitrate.

A method for the quantitative estimation of blood nitrate has been perfected. In a series of studies with sheep, receiving sodium nitrate intraruminally, it was observed that blood nitrate levels were more indicative of the level of administered nitrate than was methemaglobin.

Because of the large number of different plant species found to contain nitrate, foraging animals in Arizona experience considerable exposure to nitrate poisoning. The development of a method for determining blood nitrate will be of considerable value as a diagnostic aid and research tool.

Work planned for the coming year includes perfection of a method of determining nitrate in blood; determining the toxic action of nitrate in the animal, i.e., in addition to the presently known inhibition of oxygen transport; and determining the influence of subclinical levels of dietary nitrate on the utilization of other nutrients.

2. INFECTIOUS KERATITIS IN CATTLE.

Project Number: 199. Funds: Hatch and State Research. Personnel: W. J. Pistor, R. J. Trautman, Ned W. Rokey and R. E. Watts.

All of the previous studies on infectious keratitis have been reviewed. The etiology of this disease has not been established. With additional personnel and improved isolation quarters, the project is being rewritten to repeat the bacteriological and histopathological studies of the eye.

Benefits this year have been negligible because of the limited work done on the project. There have been continued recommendations to stockmen to not over-treat cases.

Revision of the project with objectives directed at the bacteriological studies is planned for next year. This can be better accomplished at the isolation building.

3. DIAGNOSTIC LABORATORY SERVICE.

Project Number: 339. Funds: State Research. Personnel: W. J. Pistor, R. E. Reed, N. W. Rokey, R. E. Watts, L. W. Dewhirst, R. J. Trautman, R. H. Diven, Homer Erling, V. N. Snell.

A total of 20,602 laboratory tests was conducted during the year. The tests included bacteriology, serology, necropsy, toxicology, parasitology, histopathology and hematology. The breakdown of these tests is as follows:

Bovine	9,263
Equine	137
Swine	206
Milk and water	194
Plant analyses	192
Poultry	10,060
Miscellaneous	550
	20,602

Ambulatory calls to farms (health supervision of university herds):

Disease control tests and vaccinations	819
Reproductive problems	420
Surgery and treatments	242
	1,481

These are services which are beneficial to industry. Arizona does not have another laboratory or state department of agriculture to render this diagnostic service.

Continued services with a trend to more research is planned for next year.

4. HEMOGLOBINURIA IN PASTURE-FED AND RANGE CATTLE.

Project Number: 397. Funds: Hatch and State Research. Personnel: W. J. Pistor, Ned Rokey, Robert Trautman.

A total of one hundred and twenty capillary tube agglutinations was done on serums submitted to the laboratory.

Seven bovine serums from one herd of cattle were considered positive and one canine sample was a strong reactor.

Flourescent antibody techniques were attempted in an effort to facilitate detection of organisms in urine samples. Thus far this technique has been unsuccessful.

Many veterinarians are controlling leptospira by the use of attenuated vaccine. We have been unable to evaluate this because of a relationship in outbreaks to animals grazing on green succulent pastures.

Control of disease improved by proper diagnosis in the laboratory and the combined use of bacterin and pasture management.

Attempts to determine the relation of leptospira and cattle grazing on green pastures are planned for next year. This may be possible since new equipment and a biochemist have been added to the department.

5. INTERNAL PARASITES IN RANGE, PASTURE AND FEEDLOT CATTLE.

Project Number: 422. Funds: Hatch and State Research. Personnel: L. W. Dewhirst, W. J. Pistor, R. J. Trautman.

A total of 1587 fecal samples from Arizona cattle was examined for the presence of ova of internal parasites. The average egg per gram (EPG) count of all samples was 98. Forty samples from pasture cattle revealed an average count of 306, while 1159 samples from feedlot cattle had an average count of 114, and 388 samples from range cattle yielded an average of 26 EPG.

Anthelmintic tests utilizing Co-Ral, Phenothiazine and Ruelene on a total of 300 head of feedlot cattle in three herds showed that Co-Ral as a spray and Ruelene as a feed additive or a drench significantly reduced the EPG count when compared to infected, untreated controls. Ruelene as a "pour-on" or an intraperitoneal injection did not significantly lower the egg count. Phenothiazine was also relatively ineffective.

Limited studies on weight gains indicated that treatment with Co-Ral improved the average daily gain while Ruelene and Phenothiazine had little or no effect on the average daily gain when compared to untreated control animals.

Work on the parasite burden in the various classes of cattle will serve to pinpoint the most dangerous areas. Research on the efficacy of promising anthelmintics will serve to indicate materials which are most effective. Weight gain studies have been long neglected and findings in this area should help to point out the need for proper anthelmintic treatment.

6. A STUDY OF CYSTICERCOSIS IN CATTLE.

Project Number: 428. Funds: NIH Grant. Personnel: L. W. Dewhirst, R. J. Trautman, R. E. Reed.

Efforts to discover a practical means for the antemortem diagnosis of bovine cysticercosis have not, as yet, yielded consistent positive results. Results of research on infected and uninfected animals showed that infection of cattle with

Cysticercus bovis does not produce a significant change in the per cent of hemoglobin, packed cell volume, total red cell count, total white cell count or differential white cell count. Serum protein analysis is not at this time complete, but does not look particularly encouraging.

Precipitin reactions with two different antigens were highly variable with positive reactions being obtained with antigen dilutions as high as 1 to 4000 at 6 to 8 weeks post infection.

The most promising tests appear to be an intradermal test utilizing an antigen prepared from the cysticerci and a hemagglutination test. With the latter, utilizing two antigens and fresh or formalized cells, titers of 1 to 6400 were obtained from some infected animals. Average titers from uninfected animals were never above 1 to 400.

Studies on the pathogenesis of infection prove that infections of this kind do not produce measurable hematological changes. Research on skin tests and serological tests suggests that the antemortem diagnosis of beef measles is a distinct possibility.

Similar research will be continued. Attempts will be made to infect other more easily maintained laboratory animals. Serum-agar double diffusion studies will be attempted in order to find a more specific antigen.

7. COCCIDIOIDOMYCOSIS IN ANIMALS.

Project Number: 439. Funds: State Research. Personnel: R. E. Reed, R. J. Trautman, R. H. Diven, Manuel Straub.

Coccidioidal infections were diagnosed and confirmed in two house cats from the Tucson area. Incidental to work described below, the disease was found in tissues of three coyotes. This adds two genera to the list of mammals susceptible to natural infection and resolves the question of whether cats are susceptible or not.

This department provided facilities for a visiting pathologist during the first three months of the year. In cooperation with project workers, he dissected cadavers of 160 young, healthy dogs in a search for residual lesions of coccidioidomycosis. About 1 in 4 dogs harbored such lesions. Many tissues yielded cultures of the fungus which were confirmed as coccidioidal by mouse inoculation. These cultures, along with several from cattle and additional isolates from dogs,have been maintained on Sabouraud's agar pending assay of virulence in Namru mice.

Tissues from one infected cat were forwarded to the Armed Forces Institute of Pathology as study material. A severely disseminated canine infection provided tissues which were forwarded to the Ontario Veterinary College, Guelph, Ontario for similar purposes.

Additional information regarding the relative susceptibility of the dog to coccidioidomycosis has been gained which further enhances the dog's value as an

experimental animal. Definite knowledge that two more genera are susceptible to the disease is of some academic value.

An avirulent strain of Coccidioides will be sought among the cultures on hand in hope of finding an organism that will confer immunity without producing disease. Clinical observation of the disease in dogs will be expanded to include several recently available test procedures, results of which may indicate means by which the organism produces disease.

8. LONGEVITY OF INFECTIVE LARVAE AND QUANTITATIVE DIAGNOSIS OF BOVINE NEMATODIASIS.

Project Number: 462 (W-35). Funds: Hatch and State Research. Personnel: L. W. Dewhirst, R. E. Reed, R. J. Trautman.

Larvae of internal parasites which reached the infective state were more capable of surviving periods of ecological stress than were the preinfective stages. The predominant factor in the development and survival of infective larvae in Arizona is the amount of available moisture. However, such factors as temperature, forage growth and management can play an important part in their longevity. Cattle pastured on temporary summer desert pastures in Arizona are not likely to be exposed to appreciable numbers of infective larvae. During late spring, summer and early fall, irrigated bermudagrass pastures normally provide optimum ecological conditions for the development and survival of infective larvae.

In vitro tests using Guthion and Fumazone at 5 and 50 parts per million showed that neither material was effective in decreasing the number of larvae developing to the infective stage.

Findings show that the utilization of temporary summer desert pasture for grazing purposes is not normally conducive to a dangerous build-up in parasite populations. Studies on the survival of infective larvae help to pinpoint the areas of maximum danger such as irrigated bermudagrass pastures. Studies with two nematocides showed that neither Guthion nor Fumazone is effective in preventing the development of infective larvae.

Studies relative to role of management and grass types will be expanded to more clearly define factors allowing for tremendous build-ups of infective larvae on bermudagrass pastures.

9. STUDIES ON BEEF MEASLES.

Project Number: 475. Funds: State Research. Personnel: L. W. Dewhirst, W. J. Pistor, R. E. Reed, R. J. Trautman.

Viability tests on fresh cysticerci from infected cattle revealed considerable variation. Cysticerci from 8 infected steers were found to range from completely viable and capable of evaginating in a 5% sodium taurocholate solution to ones which were completely necrosed with some deposition of calcium. Both conditions with intermediate gradations were found in a single animal but the majority of cysticerci from a single animal tended toward the same condition.

Complete examination of these carcasses showed that prescribed United States Department of Agriculture examination procedures for detecting tapeworm cysts are probably inadequate in some cases where an animal is lightly infected.

Attempts to produce in vitro hatching of Taenia saginata ova were discouraging. While treatment of ova with digestive solutions or a dilute solution of sodium hyochlorite would destroy the egg shell, larvae hatched in this manner were found to be nonviable.

Results should suggest that prescribed examination procedures of carcasses for bovine cysticercosis are inadequate to prevent some lightly infected carcasses from being passed as clean.

This project will be rewritten to outline objectives more nearly in keeping with current efforts.

10. PRELIMINARY STUDY OF THE ETIOLOGY OF MORTALITY OF YOUNG CALVES.

Project Number: 476. Funds: State Research. Personnel: Ned W. Rokey, Homer G. Erling and V. N. Snell.

Two hundred fifty-two calves, 1 to 90 days of age, were examined. Clinical signs, necropsy lesions, bacteriological and histopathological findings were recorded. Various bacteriological agents were encountered: Pseudomonas spp., Proteus spp., Paracolon spp., Leptospira spp., Salmonella spp., and coliforms. No attempt was made to identify viral agents. One hundred thirty, or approximately 51.6 per cent, of the calves were harboring one or more of 15 Salmonella serotypes. In order of frequency of isolation, these were: S. typhimurium, S. newport, S. dublin, and S. anatum. Bacteriological examination of feed samples, milk replacer, water and colostrum was made in an attempt to determine possible sources of infection. Feed and water were not incriminated as a direct cause of salmonellosis. Necropsy lesions in dead and dying calves indicate that possible routes of infection are in the umbilical artery or by oral ingestion. Pneumonia is not an uncommon sequela. Results of the investigations indicate that the calf syndrome is of a septicemic nature rather than a dietary involvement. Examination of aborted feti and frozen semen was continued. Further supporting the hypothesis of intrauterine infections is the fact that Salmonella organisms were isolated from four full-term calves which died at or prior to parturition. In addition, S. dublin was isolated from a calf born two weeks prematurely.

A high rate of calf mortality may be expected where sanitation, husbandry and management are less than desirable. In some herds, strict application of these principles appears to have considerably lowered the rate of morbidity and mortality. Experimental bacterins and hyperimmune homologous antisera have been developed and are currently under critical evaluation. This work is not yet complete.

Work conducted to date rather conclusively indicates that salmonellosis is a major cause of calf mortality in this area. Nutritional imbalance and concurrent viral infections may be contributing factors. Probable routes of infection are oral ingestion and/or navel infection. Intrauterine route cannot be overlooked.

The high incidence of salmonellosis in calves represents a potential reservoir of infection for man and should be of importance to public health officials.

Work planned for next year includes a revision of this project.

11. PILOT STUDIES - SALMONELLA DUBLIN.

Project Number: 481. Funds: State Research. Personnel: Ned W. Rokey, Homer G. Erling and V. N. Snell.

Incidence survey of S. dublin infection has been continued. Thirty-eight of 252, or 15%, of all calves 1 to 90 days old, were harboring S. dublin. In this age group, 29.2% of salmonellosis encountered could be attributed to S. dublin. The organism has been incriminated and held responsible for a high rate of mortality in yearling steers. S. dublin was isolated from a quarter of a milk cow. The cow showed no clinical evidence of mastitis. Sporadic outbreaks have occurred in other species.

Pilot studies were undertaken to reproduce the clinical aspects of the disease in calves as it occurs under natural condition. Massive doses were necessary to reproduce the condition. Minimum lethal doses for oral and i.v. routes of infection have been determined. Clinical signs, necropsy lesions, histopathological and hematological findings were recorded. A marked leukopenia was regularly demonstrated. This reduction may be the result of interstitial mobilization, vascular depletion or perhaps concurrent viral infections. The exact cause awaits further investigation. Fifty of 105 bovine sera selected at random were positive to an experimental flagellar S. dublin antigen. Agglutinations were in dilutions of 1:100 or higher.

In vitro sensitivity tests have been conducted on approximately 50 S. dublin cultures. Those drugs showing in vitro activity will be used for future in vivo investigations. Pilot studies have been completed on the development of a hyperimmune S. dublin antiserum. This serum is currently under investigation. An experimental S. dublin bacterin is currently under investigation in an infected commercial dairy herd.

The true pathogenesis of S. dublin is vague and awaits further investigation. Results of these investigations further substantiate the presence and apparent increase of S. dublin infection in this area and its potential economic importance to the livestock industry.

This work is to be continued for the next year.

12. PRELIMINARY STUDIES OF FOWL SPIROCHETOSIS (BORRELIA ANSERINA) IN ARIZONA POULTRY.

Project Number: 504. Funds: State Research. Personnel: Ned W. Rokey, Homer G. Erling and V. N. Snell.

Present research results indicate sheep and rabbits are probably refractory to Borrelia anserina infection. Domestic pigeons, wild ducks, mourning doves and American coots are susceptible but refractory to clinical infection. Parakeets are extremely susceptible to artificial inoculation. There is an indication that wild ducks as well as doves may have been exposed to natural infections. Twelve of 583, or 2 per cent, of assumed susceptible chickens challenged were refractory to spirochetemia.

The spirochete is apparently highly pathogenic for mature chickens but relatively innocuous to young birds. A transitory megaloblastic anemia is associated with the disease syndrome. PCV reductions as much as 50 per cent have been observed with a mean average reduction of 32 per cent. The amplitude of spirochetemia varied from one spirochete/high-dry oil-immersion field to numbers exceeding the RBC concentration. Duration of spirochetemia varied from one day to a maximum of nine days. At terminal stages of spirochetemia, the organisms clump into masses and disappear from the blood. Temperatures ranged from 108.2 to 113.2°F. Preliminary investigations are indicative that temperature rise, duration, amplitude or duration of spirochetemia and secondary infection are probably not directly associated with mortality encountered in artificially infected birds. Recovered birds are solidly immune to reinfection.

The organism was grown in artificial media on two serial transfers but would not survive as long as 75 days in citrated whole blood held at 45°F. and retain its infectivity for chickens. The vector of B. anserina, Argas persicus, has been collected from quail and mourning dove in widely separated areas in the state.

The occurrence of A. persicus on dove and quail presents a possible natural reservoir for B. anserina. This work is to be continued for the next year.

13. COCCIDIOIDOMYCOSIS IN ANIMALS.

Project Number: 581. Funds: NIH Grant. Personnel: R. E. Reed, R. H. Diven, R. J. Trautman.

Washed mycelium of C. immitis was blended with acetone in a chilled Omni-Mixer, the acetone filtered off and the resulting powder dried at 0°C. This procedure killed the organism and provided a safe material with which to work. The powder was then suspended in various pH ranges of phosphate buffer or TRIS buffer (pH 7.5) and incubated in the Warburg with various levels of buffered glucose, phosphorylated hexoses, DPN, TPN, ATP and inhibitors such as sodium flouride. Aerobic glycolysis could not be sustained for over 30 minutes, and CO_2 release wasn't measurable, indicating inhibition of enzymatic activity. Acetone was suspect, but efforts to produce a cell-free extract by grinding were interrupted by a decision to study the yeast (spherule-endospore) phase, since information on parasitic growth would be more revealing of the in vivo metabolism of the fungus. Converse's medium has been used with the addition of glutathione, Tween 80 and sodium flouride and without sodium and calcium chloride and sodium bicarbonate. Tamol N was varied from 0.05 to 0.1% w/v. Arthrospore to spherule conversion has been obtained with 0.5% Tamol N and 0.008 M sodium flouride, but spherule reproduction hasn't been

achieved. It has been both important and difficult to control temperature of incubation.

Individual glycolytic enzymes and pathways of glycolysis were reviewed. It was decided that pyruvate analysis was the most appropriate indicator of these pathways in host and parasite, and between both, if variously C-14 labeled glucoses were used. Proper paper, strip dimensions, pretreatment (washing and buffering), extraction of pyruvate (ethyl acetate was most effective) and application to paper were worked out. Several solvents (mobile phase) were tried, glycine-sodium hydroxide being best. Chromatography was performed at room, incubator and refrigerator temperatures, none providing ideal control, indicating the necessity of running a standard control with each experimental sample.

Mice were anesthetized with intraperitoneal injections of thiamylal sodium, their abdomens opened and glucose injected via the portal veins. One minute later entire livers were removed, homogenized with iodoacetate to stop metabolism and prevent loss of pyruvate, which was then extracted and chromatographed.

All results of this year's efforts apply directly to the success or failure of work planned for next year. It is hoped that insight into metabolism of the fungus within and outside the host will reveal means of combating the infection.

Physiology of the yeast phase of Coccidioides immitis will be studied in vitre, the search being for metabolic mechanisms involved in the utilization of nutrients. Alterations in host physiology will also be sought in infected mice and dogs.

14. CANINE BABESIASIS.

Funds: State Research. Personnel: Ned W. Rokey, Homer G. Erling and V. N. Snell.

Investigations were continued in an attempt to more clearly define Babesia canis infection as a distinct clinical disease entity of dogs. A three-month-old splenectomized calf was refractory to infection when inoculated with 5cc. of infected B. canis blood; the laboratory strain of B. canis is maintained in a splenectomized dog. Challenged six-week-old puppies developed babesiasis and exhibited an intermittent fever, enlarged spleens; but showed little physical impairment of general health. There was a marked reduction on PCV and a definite polychromatic anemia. The laboratory strain of B. canis is probably innocuous to healthy six-week-old dogs.

Blood smears were stained by Giemsa's and Wright's method. During the height of infection, characteristic paired intracellular inclusions were readily demonstrated. Bizarre forms, rods, rings and dumbbells were frequently observed. During the quiescent stage, round purple-staining inclusions, approximately 2 microns in diameter, were seen in the red blood cells. During this period, characteristic inclusions could not be demonstrated.

Of 50 dogs suspected of babesiasis, the organism could be demonstrated in only three. Clinical signs in these dogs were vague. Slight icterus, anemia, intermittent fever, enlarged spleens and persistent cough were generally associated with the condition. Differential diagnosis is difficult and might be easily confused with leptospirosis.

This work shows that B. canis is present in Arizona dogs.

This work is to be discontinued.

15. A STUDY OF SALMONELLA DUBLIN IN ANIMALS.

Project Number: E-2778. Funds: NIH. Personnel: Ned W. Rokey, Homer G. Erling and V. N. Snell.

Three hundred fifty-two calves have been examined in an attempt to determine an incidence of Salmonella dublin infections. Tissues from an additional 65 calves have also been examined. These animals were passed under federal inspection. Current results indicate that the over-all incidence of S. dublin infection in calves is probably less than 15 per cent. Studies are not yet complete. Sporadic outbreaks in other species have been studied.

Preliminary investigations indicate that S. dublin may produce a characteristic disease syndrome in calves. Clinical signs and necropsy lesions are similar to those seen in natural outbreaks and may be distinct from other salmonelloses.

In an attempt to establish carrier status of cows in infected herds, 772 fecal samples were examined bacteriologically. The results were inconclusive as were the results of examinations of 95 gall bladders of mature dairy cows slaughtered at local plants. Examination of feed samples, water samples, milk replacer products, colostrum and milk were inconclusive. The epidemiology of S. dublin infections is vague and awaits further investigation.

Sensitivity tests have been conducted on approximately 50 S. dublin cultures. Those drugs showing in vitro activity will be used in future in vivo work. Pilot studies have been completed on experimental bacterins and hyperimmune homologous antiserum. These products are being evaluated in the laboratory. One pilot test has been set up in a known infected commercial dairy herd.

S. dublin is capable of producing serious losses in livestock, particularly calves. The disease is wide spread and a matter of record in Arizona.

The work is to be continued next year.

Department of
ANIMAL SCIENCE

1. INFLUENCE OF FORAGE HARVESTING AND FEEDING METHODS ON BEEF PRODUCTION.

Project Number: 248. Funds: Hatch. Personnel: W. H. Hale, Farris Hubbert, Jr., B. R. Taylor, and C. B. Roubicek.

Blue panicum grass and coastal Bermuda grass have been harvested at various dates throughout the growing season. The digestible dry matter, digestible protein, and digestible energy of the two forages are to be determined as ground and as pelleted material. The initiation of the trial has been delayed awaiting installation of the pellet mill. As soon as satisfactory pellets have been made, the digestion studies will be conducted. A trial has been completed on ground alfalfa alone, in which a cellulase enzyme has been added. Tabulation of digestibilities is not complete.

2. THE EVALUATION AND UTILIZATION OF LOW QUALITY ROUGHAGES AS FEEDS FOR LIVESTOCK IN ARIZONA.

Project Number: 388. Funds: Hatch. Personnel: Farris Hubbert, Jr., T. A. Anderson, and R. E. Taylor.

The ad libitum dry matter consumption of a roughage when fed as the only source of nutrients is probably the best single criterion for determining its nutritive value. Thirty-five percent less blue panicum hay and 46% less Bermuda straw were consumed by the steers than alfalfa hay when dry matter intake was expressed on the basis of pounds intake per 100 pounds of body weight. The roughages were found to contain 60.7%, 54.9%, and 51.5% digestible dry matter, respectively, for alfalfa, blue panicum, and Bermuda straw. The apparent digestion coefficients for the crude protein content of the respective roughages were 74.5%, 54.7%, and 31.2%. Although the blue panicum hay was found to have a crude protein content of 12.3%, it did not meet the digestible protein requirement of the animals because of the limited consumption and low apparent coefficient of crude protein digestibility. Neither blue panicum hay nor Bermuda straw would meet the minimum requirement for digestible energy for growing beef cattle.

The volatile fatty acid determinations indicated that the ratio between acetic, propionic, and butyric acids was essentially the same for all steers. However, the steers fed Bermuda straw were found to have approximately 50% lower concentration of total fatty acids per liter of rumen fluid than those fed either alfalfa hay or blue panicum hay.

3. FARM FLOCK SHEEP PRODUCTION ON SOUTHWESTERN IRRIGATED PASTURES.

Project Number: 403. Funds: Hatch. Personnel: O. F. Pahnish, C. B. Roubicek, B. R. Taylor, W. J. Van Arsdell, and John Kuhn.

Reproductive problems were encountered during the past year in the experimental sheep flock at the Yuma Branch Station. Of 79 grade Rambouillet ewes exposed to Hampshire, Suffolk, Rambouillet, and Columbia rams (15 to 17 ewes per sire) only 45% produced lambs. Of 36 blackfaced, crossbred ewes exposed to Rambouillet and Suffolk rams (17 and 19 ewes per sire) only 5.5% produced lambs.

Lack of smple time for some of the rams to adjust to the Yuma environment and possibly breed differences appear to have contributed to the poor lamb production by the Rambouillet ewes. These factors plus the high condition of the crossbred ewes may have contributed materially to the poor lamb crop yielded by the crossbred females.

4. ENVIRONMENTAL PHYSIOLOGY OF ANIMALS AND THEIR ADAPTABILITY TO HIGH TEMPERATURE STRESS.

Project Number: 411. Funds: Hatch (W-46). Personnel: C. B. Roubicek, F. E. Hubbert, Jr., B. R. Taylor, and R. E. Taylor.

A trial was conducted at the Yuma Station to determine if fans could be used to increase animal productivity in hot weather. A large airplane-type propeller fan was used when the ambient temperature was 90°F. or less and maintained a wind velocity of 10 to 15 miles per hour in the pens. In addition, 33% and 55% concentrate levels were compared. The results indicate that the concentrate ratio is of major importance in maintaining hot weather production in beef cattle. The fan gave a slight response at the 55% concentrate level. Night observations of the cattle showed that between 10:00 P.M. and 5:00 A.M., 80 to 95% of the cattle were lying down. There was a slight general activity of the animals about 1:00 A.M.

Preliminary results with rats in the psychrometric laboratory indicate that restricted rather than ad libitum feeding is of major importance in encouraging vitamin A retention.

Night cooling per se is not of major importance in maintaining productivity in hot weather. Ration and feeding method show definite promise.

5. DEVELOPMENT OF SELECTION CRITERIA FOR THE GENETIC IMPROVEMENT OF CARCASS MERIT IN SHEEP.

Project Number: 484 (W-61). Funds: Hatch. Personnel: C. B. Roubicek, O. F. Pahnish, F. E. Hubbert, Jr., B. R. Taylor, and R. E. Taylor.

The initial study, started last year with 30 wether lambs, has been completed. The carcasses were separated into five wholesale cuts. Grid photographs were taken of each cut surface and the wholesale cuts were then boned and homogenized. A sample of the homogenized material was chemically analyzed for moisture, fat, and protein.

The body composition of the carcasses ranged from 18.84% fat to 42.14% fat; protein ranged from 10.19% to 18.81%.

Statistical analysis of the data indicates that the chemical analysis of the shoulder is more indicative of carcass composition than any other wholesale cut. Correlation coefficients for shoulder with entire carcass were .265 for fat, .560 for protein, and .802 for bone. Grid photograph measurement data indicate that the fifth rib cut is most indicative of carcass protein and fat in the carcass with a correlation of .28.

Data are limited and cannot be used for final conclusions.

6. BREEDING AND SELECTION OF BEEF CATTLE FOR THE SOUTHWEST.

Project Number: 500. Funds: Regional Research and Hatch. Personnel: O. F. Pahnish, C. B. Roubicek, E. B. Stanley, Farris Hubbert, Jr., W. H. Hale, A. M. Lane, and graduate students.

Data collected at weaning time in the Apache Tribal Herd at San Carlos, Arizona, over a three-year period, were analyzed statistically. All calves were purebred Herefords (bulls and heifers) produced under range conditions and weaned at an average age of 226 days.

Bull calves averaged 32 pounds heavier than heifers and gained 0.12 pound more per day over the three-year period, but these sex differences varied from year to year (20 to 41 pounds and 0.06 to 0.16 pound). Average sex differences as sex adjustment factors thus do not appear as accurate as is desirable for use in beef cattle selection work. Mean sex differences computed within ranches and within years should be more realistic if herds are large. Multiplicative factors may have a relatively broad application and will be tested further.

Heifers scored somewhat higher than bulls in both conformation and condition. A more advanced stage of maturity might account for the higher heifer scores.

All traits studied were influenced significantly ($P < .01$) by age of dam. Age-of-dam adjustments computed were:

Age-of-dam	Weaning weight	Daily gain	Scores	
			Conformation	Condition
3, 4, 11	21 lbs.	0.08 lb.	0.3	0.3
5, 10	10 lbs.	0.04 lb.	0	0
6, 7, 8, 9	0	0	0	0

Sires influenced all traits except condition. Seventeen sires were compared. Differences among sire means were: weaning weight 65 lbs., daily gain 0.25 lb., conformation score 1.4.

7. A QUANTITATIVE AND QUALITATIVE EVALUATION OF THE GRAZING ANIMAL'S DIET WITH SPECIAL EMPHASIS ON RUMEN MICROORGANISM ACTIVITY AS INFLUENCED BY FORAGE SPECIES, STAGE OF FORAGE MATURITY AND CLIMATIC ENVIRONMENT.

Project Number: 511 (W-34).. Funds: Hatch. Personnel: Farris Hubbert, Jr., R. E. Taylor, and N. G. Elliston.

The main forage producing grass (Boutelona gracilis) was found to be deficient in both crude protein and phosphorus content during both 1958 and 1959 with the exception of approximately a two-month period following the onset of the summer rains. However, it was found that certain species (Stanion hystrix and Panicum obtusum) contained relatively high concentrations of crude protein and phosphorus during the low rainfall periods.

Studies of the influence of sample size, fineness of grind, and time of digestion were conducted with the "nylon bag" technique, utilizing rumen fistulated steers. It was determined that cellulose digestibility following a digestion period of at least 48 hours will provide the best simple evaluation of range forage quality. Sample size and fineness of grind were found to have no significant influence on the results obtained.

Procedures for conducting artificial rumen evaluations of forage quality and volatile fatty acid determinations on rumen fluid were developed for our laboratory.

8. EFFECT OF THERMAL STRESS ON VITAMIN A REQUIREMENTS.

Project Number: 2RC-PHS-170(607). Funds: Public Health Service. Personnel: C. B. Roubicek, F. E. Hubbert, Jr., and R. E. Taylor.

Weanling, Sprague-Dawley, male rats were used to test the effect of high temperature, protein source, and method of feeding on liver vitamin A. It was found that animals at constant 95°F. showed weight gain advantage over control animals maintained at 70°F. Animals on restricted feeding, compared to ad libitum feeding, showed the most pronounced effect. They also showed a higher hepatic vitamin A content at 95°F. Rats in the 95° room consumed two to three times more water than those in the 70° room. The total serum protein (gram %) and the albumin-globulin ratio were increased at 95° compared to 70°. Level of vitamin A in the diet had no apparent effect.

The method of feeding (restricted or ad libitum) appears to be an important factor in determining animal response at high environmental temperature.

9. VITAMIN A AND CAROTENE UTILIZATION IN DEFICIENT RUMINANTS.

Funds: Public Health Service. Personnel: Farris Hubbert, Jr., T. A. Anderson, C. B. Roubicek, and R. E. Taylor.

The influence of protein depletion on vitamin A and carotene utilization by vitamin A deficient sheep was studied with 36 mature ewes and wethers. All animals were fed a carotene and vitamin A-deficient diet for over 200 days to deplete their store of hepatic vitamin A. Half of the animals were then fed a protein-deficient ration for 50 days which was followed by a 28-day period during which three treatments (control, oral vitamin A and oral beta carotene) were superimposed on the protein treatments. This was followed by a 28-day protein-repletion period for the animals made protein-deficient. Blood samples

were taken at seven-day intervals throughout the experiment and liver biopsy samples were taken at the end of each phase (three samples per animal).

The following relationships were found: (1) Protein-deficient sheep had significantly lower serum albumin and hematocrit levels than sheep on adequate protein. (2) Plasma and liver vitamin A values appeared to be lower in the protein-depleted animals. (3) Vitamin A and carotene administration appeared to be more effective in the sheep fed adequate protein level. (4) Total serum protein levels were higher in the sheep supplemented with vitamin A compared with control animals, regardless of the protein level of the ration.

Three trials have been conducted with weanling rats as the experimental animal to study the influence of protein quality of the diet (casein or zein), method of feeding (restricted intake or ad libitum), and ambient temperature (70 or 95°F.) on the utilization of vitamin A by the vitamin A-deficient rat. One trial also included a study of the influence of supplementing zein with lysine and zein as compared to zein and casein alone as the protein source of the diet. Response has been measured in terms of feed intake, water consumption, body weight gain, total serum protein, serum protein fractions and hepatic storage of vitamin A. The analysis of the data collected in these trials has not been completed.

10. IMPROVEMENT OF ARIZONA FEEDLOT RATIONS.

Funds: State. Personnel: Farris Hubbert, Jr., John Kuhn, and B. R. Taylor.

The study was conducted with 16 pens of seven yearling steers each from January 21 to April 27, 1960 at the Yuma Experiment Station. The experiment was conducted as a factorial with protein level (10 and 13%), calcium addition (0 and 0.1%), and tallow addition (0 and 4%) as the factors. The objective of the work was to determine whether the protein or calcium level of the ration would have any influence on the performance of animals fed tallow to increase the energy content of the ration.

The high protein ration resulted in an over-all increase in average daily gain of 0.2 pound per day and a saving of 90 pounds of feed per 100 pounds of gain. The addition of tallow had a slight depressing influence on rate of gain in all cases but resulted in an increase in feed conversion similar to that obtained from the high protein treatment. The combination of high protein and tallow was found to have an additive influence on feed conversion resulting in a saving of approximately 180 pounds of feed per 100 pounds of gain.

The addition of calcium was without influence on rate or economy of gain.

11. IMPROVEMENT OF ARIZONA FEEDLOT RATIONS.

Funds: State. Personnel: Farris Hubbert, Jr. and B. R. Taylor.

Seventy Hereford or Hereford X Angus crossbred yearling steers were fed in ten pens of seven animals each from January 6 through May 12, 1960.

The objectives of the study were: (1) To determine whether a beef cattle fattening ration containing 14% crude protein would result in more rapid and efficient gains than one containing 10% crude protein. (2) To determine whether providing 0.02 pound of phosphorus per pound of dietary protein would result in as efficient feedlot gains as a ration containing 0.04 pound of phosphorus per pound of protein.

The steers receiving the 14% crude ration gained an average of 0.27 pound per day faster than those receiving the 10% crude protein ration. Efficiency of feed conversion was also slightly in favor of the animals being fed the high protein ration. However, the extra cost of the high protein ration nullified any economic advantage that might be expected from 14% crude protein ration.

The addition of the high level of phosphorus, as dicalcium phosphate, did not increase either rate or efficiency of gain with either the 10 or 14% crude protein rations.

12. IMPROVEMENT OF ARIZONA FEEDLOT RATIONS.

Funds: State. Personnel: Farris Hubbert, Jr. and B. R. Taylor.

Two feedlot trials were conducted during 1960 to determine: (1) Whether steam-rolling either milo or barley will result in more rapid and efficient feedlot gains than dry-rolling. (2) To determine the comparative value of milo and barley when used as the main concentrate portion of the fattening ration for beef cattle.

The first trial was conducted from January 6 through May 12, 1960 (winter trial) and the second from July 7 through September 29, 1960 (summer trial). Eight pens of seven yearling steers each were used in the first trial and 16 pens of eight steers each were fed in the summer trial.

Winter trial. During the winter feeding trial it was found that steam-rolling barley as compared to dry-rolling resulted in a 6.5% increase in rate of gain and a 5% saving in feed required per unit of gain. However, no advantage was found for steam-rolling milo.

Barley was found to increase the rate of gain 5.6% and resulted in a 16% increase in efficiency of feed conversion to gain as compared to milo.

Summer trial. The summer trial was conducted as a 2 x 2 x 2 factorial experiment with barley vs. milo, steam-rolling vs. dry-rolling and 10% crude protein vs. 14% crude protein as the factors. There were no significant treatment differences or interactions found in the trial.

13. IMPROVEMENT OF ARIZONA FEEDLOT RATIONS.

Funds: State. Personnel: Farris Hubbert, Jr., W. T. Hayer, III, and R. E. Taylor.

This trial was conducted to evaluate the use of either steam- or dry-rolled barley when fed as the only feedstuff in addition to a protein supplement in a beef cattle fattening ration. Nine yearling steers were fed the all-barley ration for a 111-day period extending from May 31 to September 19, 1960.

The study was conducted so that four steers received dry-rolled barley during the first 53 days and steam-rolled barley during the remainder of the trial. Five steers were fed steam-rolled barley first and dry-rolled barley during the final phase. In addition, two steers on each kind of barley were fed 100 grams of a barley malt enzyme product (Wisyme A) during the last 37 days of the study.

No differences in rate of gain or feed conversion were found due to either steam- or dry-rolling barley.

No significant differences were found in the apparent digestibility of gross energy, crude protein or starch. The digestion coefficients obtained during the first and second periods respectively were: gross energy, 78.1-81.0; crude protein, 74.5-76.4; and, starch, 96.5-95.2.

Volatile fatty acid determinations were made on rumen fluid samples collected from all steers. No differences due to barley treatment were noted. However, it was found that molar percent of acetic and propionic acids was approximately 1:1 rather than 2:1 as normally found on high roughage rations. The livers of the steers were found to be devoid of vitamin A at the end of the feeding period in spite of the fact they were supplemented with vitamin A at a level slightly higher than the requirements listed by the National Research Council Committee on beef cattle nutrition.

14. TOXICITY OF ORAL VITAMIN A SUPPLEMENTATION WITH BEEF CATTLE.

Funds: State. Personnel: W. H. Hale, Farris Hubbert, Jr., B. R. Taylor, and C. B. Roubicek.

Twelve steers were allotted to six feeding levels of vitamin A. All steers were individually fed a low carotene, 65% concentrate ration. The following vitamin A levels were fed per steer daily: (1) none; (2) 10,000 I.U.; (3) 40,000 I.U.; (4) 160,000 I.U.; (5) 640,000 I.U.; and (6) 2,560,000 I.U. The steers were biopsied at the initiation of the experiment and at regular intervals thereafter.

No apparent signs of vitamin A toxicity have developed at 84 days. Performance for all steers can be considered good with no reduction in performance due to the high level of vitamin A supplementation.

There appears to be no relationship between plasma vitamin A and liver vitamin A other than a higher plasma level with the high level supplementation. This increase, however, is not proportionate to liver increases.

Liver vitamin A values are proportional to level of vitamin A being fed; however, the 10,000 I.U. level will not maintain liver levels at the initial values.

Salt intake with the three higher levels of supplementation is several times greater than with the three lower levels.

It would appear that vitamin A toxicity is of no practical concern with fattening steers.

15. EVALUATION OF DIAMMONIUM PHOSPHATE AS A NON-PROTEIN NITROGEN SOURCE FOR ANIMALS.

Funds: State. Personnel: W. H. Hale, E. L. Russell, Jr., and Farris Hubbert, Jr.

In many fattening rations for steers urea replaces a portion of the natural protein and phosphorus is added to assure adequate phosphorus nutrition for the animal. Urea, at high levels, is toxic and the nitrogen from urea may be poorly utilized. A non-protein nitrogen compcund less toxic than urea would be highly useful in the cattle feeding industry. Diammonium phosphate is unique in that both non-protein nitrogen and phosphorus are combined in the same molecule.

Toxicity studies with diammonium phosphate using the drench method show urea to be approximately three times more toxic than diammonium phosphate. Twenty-four-hour urinary nitrogen excretion studies in conjunction with the toxicity studies show similar nitrogen excretion for the two compounds.

Detailed nitrogen balance studies and urinary phosphorus excretion studies are under way.

The data collected to date indicate that diammonium phosphate may be a more satisfactory non-protein nitrogen compound than is urea.

Department of
BOTANY

1. INVESTIGATIONS ON THE STOMATAL MECHANISM.

Project Number: 385. Funds: Hatch. Personnel: Robert M. Harris.

Transpiration studies of a number of cacti; Carnegiea gigantea, Opuntia versicolor, Echinocactus Wislizenii, Cereus Schottii have been made. All representatives of these species show a regular diurnal periodicity of transpiration. Stomatal transpiration is greatest in the light and little, if any, occurs in the dark. These studies were prompted by literature references to the contrary.

Laboratory studies on Carnegiea gigantea (Saguaro cactus) indicate that these plants absorb atmospheric moisture when the relative humidity approximates 100 per cent.

2. ROOT DEVELOPMENT OF FORAGE CROP SPECIES AS INFLUENCED BY PHYSICAL AND CHEMICAL FACTORS OF THE SOIL.

Project Number: 427 (W-47). Funds: Hatch. Personnel: W. S. Phillips, Kaoru Matsuda, Albert T. Ellis.

Work was mainly on osmotic concentrations as they affect excised dicot roots. Studies using sucrose and osmotically equivalent amounts of NaCl were carried out on alfalfa and cucumbers. Variatal differences were found in the alfalfas but in general alfalfa responded best in solutions at 4.8 atmospheres.

Comparisons of sucrose with NaCl showed salt to be much more of a growth inhibitor on Lahontan alfalfa than osmotically equivalent amounts of sucrose. Differences using cucumbers were less conspicuous since extensive root growth did not occur under any of the conditions. However, inhibition of secondary root formation in cucumbers occurred at lower osmotic values in salt than in sucrose solutions.

3. SOME ENVIRONMENTAL REQUIREMENTS OF CANDELILLA, A POTENTIAL WAX PLANT FOR THE SOUTHWEST.

Project Number: 498. Funds: Hatch. Personnel: Edwin B. Kurtz.

Seventy-five soil samples from a community of candelilla in Big Bend, Texas, have been analyzed to determine some soil requirements of candelilla. The soil type is quite heavy and alkaline with the following characteristics:

sand, 46 - 68%, average 52%
silt, 18 - 51%, average 31%
clay, 7 - 24%, average 17%
pH, 7.1 - 9.3, average 8.8%
$CaCO_3$, 6.2 - 12.7%, average 9.4%

This information is being used in the design of several mineral nutrition studies. Six photoperiod chambers are under construction for the purpose of determining day length responses (wax production, growth, flowering). A preliminary study suggests that candelilla is a long day plant.

4. VEGETATIONAL CHANGES - GREAT PLAINS (GRASSLAND, USA).

Project Number: 2RC ONR. Funds: Non-Federal. Personnel: W. S. Phillips and Freeman Smith.

During August of 1960 I covered 8000 miles in Montana, North and South Dakota, Nebraska, and Wyoming. During this trip I was able to get enough additional information and pictures to be able to complete the Great Plains part of this project. Pairs of pictures are being studied and notes of recent trips compared with H. L. Shantz' original notes.

Work on the Arizona part of this project is being carried on at the same time. Trips, mostly weekend, are being made and pictures of the area around Tucson taken and compared. Rod Hastings of the Atmospheric Physics Department is using the pictures of Saguaro National Monument to supplement his studies and past history of the vegetation. Two graduate students have been using this material for supplementary studies on local conditions of vegetation change.

5. PHYSIOLOGICAL GENETIC STUDIES ON STATURE MUTANTS OF MAIZE.

Funds: Non-Federal.

Anatomical studies of stature mutant $nana^{-2}$ show that embryonic coleoptiles and mesocotyls of the mutant do not differ significantly from the normal in length, width, cell numbers or lengths of cells. However, three-day-old seedlings of $nana^{-2}$ do differ from the normal in the shorter length of the coleoptiles and mesocotyls and in the shorter length of the cells within these structures.

Auxin assays indicate that $nana^{-2}$ produces from 20-25 per cent as much auxin as the normal sibling. $Nana^{-2}$ does not respond to either IAA or gibberellins.

6. GENETIC STUDIES OF TASTER TRAITS.

Funds: Non-Federal. Personnel: Robert M. Harris and Albert T. Ellis.

Acetone extracts of the fruit of Colocynthis citrullis yielded the compound citbittol. The citbittol was dissolved in alcohol to produce a .1% solution. This solution was then used to impregnate filter paper with the citbittol.

Of the 464 Caucasian students surveyed, 20 individuals were unable to taste the compound. These figures would represent a frequency of 4.32 citbittol non-taster individuals in every one hundred individuals of the population. Subsequent studies of the 20 non-taster individuals indicate that the gene for the non-taster is recessive to taster and that it is inherited independently of PTC and brucine taster genes.

If the gene for citbittol non-taster is recessive and the frequency of the non-taster genotype is 4.32% then the gene frequency in the population studied would be 21%.

7. CHROMOSOME BREAKAGE IN VICIA FABA.

Funds: Non-Federal. Personnel: Oscar G. Ward, Jr., Hallard T. Murray, Jr. and Robert M. Harris.

The effects of unracil, asparagine, adenine and nicotine on the production of chromosomal aberrations in the legume, Vicia faba, were determined. Also investigated were the chromosome-breaking effects of a water extract of Vicia seeds on growing Vicia plants.

Significant aberrations were obtained with nicotine and water extract treatments. Nicotine was found to produce, in addition to other aberrations, longitudinal splitting and somatic pairing of the chromosomes. Although the water extract of Vicia seeds did not produce aberrations as unusual as those obtained with nicotine, the fact that the extract could produce aberrations at all, suggests a "built-in" mechanism for genetic change.

8. NUTRITION OF SORGHUM.

Funds: Non-Federal. Personnel: Edwin B. Kurtz and R. H. Maier.

Analysis of plants grown in nutrient solutions of a wide pH range (4 to 12) for their iron content has been repeated and confirmed.

9. THE PROPAGATION OF CANDELILLA AND A STUDY OF THE SYNTHESIS OF WAX IN PLANTS.

Funds: Non-Federal. Personnel: Edwin B. Kurtz and Kaoru Matsuda.

Numerous studies on the biosynthesis of wax constituents in candelilla are being concluded and summarized in a doctoral thesis.

10. STUDIES ON THE SAGUARO CACTUS (CARNEGIEA GIGANTEA).

Funds: Non-Federal. Personnel: Edwin B. Kurtz, Stanley M. Alcorn, and others.

Interdisciplinary studies on the physiology, chemistry, and ecology of the saguaro cactus have been continued and extended. Several areas of research have been published or are in press.

11. THE SYNTHESIS OF FATTY ACIDS IN A HIGHER PLANT (USAEC).

Funds: Non-Federal. Personnel: Edwin B. Kurtz and Leslie F. Smith.

There are at least two, possibly three, light processes in flax embryos that are involved in the utilization of acetate in the synthesis of fatty acids. One reaction concerning low intensity red and far-red light, has inductive effects; far-red light irreversibly inhibits conversion of acetate to CO_2. A second reaction at higher light intensities (approx. 300 ft.-c.), concerns the use of visible light as an energy source for metabolic power. A third reaction, which may be distinct from the first reaction, concerns the interconversion of long-chain fatty acids. The requirement of biotin for fat synthesis cannot be replaced by light.

12. UNIVERSITY OF ARIZONA HERBARIUM, STATE PROJECT #327.

Funds: Non-Federal. Personnel: Charles T. Mason, Jr.

During the past year 4,293 new specimens were added to the herbarium. Exchange with other institutions continued with 1,589 specimens being received and 1,859 specimens sent. Four institutions were added to our exchange list including the University of Vermont which sent 523 specimens collected by C. G. Pringle in Arizona and Mexico during the first part of this century.

Loan activity during the year remained brisk; 1,114 specimens were sent on loan, and we now have a total of 1,715 specimens outstanding. The University of Arizona herbarium is charged with 758 specimens borrowed from other institutions for various workers on campus.

Research on the Perennial Gentains of the section Pneumonanthe is continuing. The National Science Foundation grant terminated but considerable data have been collected and await evaluation.

Department of
DAIRY SCIENCE

1. THE RELATION OF THE PROTEIN CONTENT TO THE DIGESTIBLE ENERGY AND PRODUCTIVE VALUE OF ALFAIFA HAY FOR DAIRY COWS.

Project Number: 448. Funds: Hatch. Personnel: G. H. Stott.

It has been found that limiting roughage intake in dairy rations during periods of high temperature physiological stress can be lowered, resulting in better milk production and fertility in lactating dairy cows. Based on average production per cow per day, cows limited to 1.5 pounds of alfalfa hay per 100 pounds of body weight produced 2 pounds nonfat, corrected milk, had 0.06 higher solids nonfat test, and produced 0.39 pounds more solids than control cows. Because the cows on low fiber feed maintained a higher production and a better reproductive performance, only 5 were culled out of 43, compared to 15 in the control group.

2. THE RELATION OF HIGH ENVIRONMENTAL TEMPERATURE TO REPRODUCTIVE PERFORMANCE.

Project Number: 449. Funds: Hatch. Personnel: G. H. Stott.

Hormones have been used in an attempt to improve the low breeding efficiency during the summer months in Arizona. Progesterone and a gonadotrophin (P.M.S.) were injected at low levels at the beginning of estrus in one group of cows (59 head) to speed up ovulation and prevent anovulation and early embryonic death previously observed. The cows were examined at 12-hour intervals from beginning of estrus to determine if and when ovulation occurred. No improvement was found in the hormone treated cows over controls in time of ovulation or embryonic death.

A second group of cows were treated with 500 mg. of progesterone, 49 head at the time of insemination and the 39 head at 10 days post-insemination, in an attempt to prevent embryonic death. Again, no improvement was shown over the control animals.

3. MOBILIZATION AND ABSORPTION OF CALCIUM AND PHOSPHORUS BY CATTLE.

Project Number: 446. Funds: Hatch. Personnel: G. H. Stott and Vearl R. Smith.

I. Parathyroidectomy of lactating or late gestating bovine does not depress milk secretion from expected levels as long as sufficient nutrients with proper calcium and phosphorus content are provided. However, where parathyroidectomy is performed prior to the "making up" or development of mammary tissue, milk secretion is practically nil. This is not true when bovine are thyroidectomized alone.

II. Extraneous sources of growth hormone are known to increase milk secretion dramatically in dairy cows. Injections into lactating cows that were thyroidectomized and parathyroidectomized demonstrated that the lactogenic effect is not dependent on either of these endocrine glands.

III. Reducing the dietary calcium intake in parathyroidectomized cows lowered their serum calcium. When given mono-sodium phosphate as extra phosphorus supplement no increase in serum calcium was noted. However, when the same cows were placed on a regular diet high in calcium, additional phoshporus supplement sharply increased serum, indicating an increased calcium absorption.

4. EXPERIMENTAL MODIFICATION OF SPERMATOGENESIS IN YOUNG BULLS.

Project Number: 465 (W-49). Funds: Hatch. Personnel: Robert G. Fossland.

Twenty-one Guernsey and Holstein bulls between ages of 4 and 10 months were unilaterally orchectomized, following which they were treated with FSH (Armour); growth hormone (Somar Armour); Lactogenic hormone (Pantilar-Armour); progesterone and testosterone. At intervals of 3-4 weeks the second testis was removed. Segments of both testes were fixed, imbedded and sectioned for microscopic examination.

FSH accelerated the activity of the primary spermatocytes and increased the diameter of the seminiferous tubules. Growth hormone stimulated rate of division of primary spermatocytes and the completion of the spermatogenic process. Some gain in body weight was noted. The administration of lactogenic hormone appeared to retard spermatogenesis. Results with estradiol were conflicting. One animal showed no change, two regressed and the youngest bull (6 mo.) seemed to show accelerated development. Results using progesterone were negative. A slight acceleration was observed with testosterone.

5. THE CONSUMER ACCEPTANCE OF MILK BEVERAGES AS AFFECTED BY FAT AND SOLIDS-NOT-FAT CONTENT.

Project Number: 483. Funds: American Dairy Association. Personnel: J. W. Stull and J. S. Hillman.

250 family units were provided with milk beverages of various composition for six weeks. Preference observations were recorded by questionnaire. It was found that the addition of 1% solids-not-fat (SNF) significantly improved the flavor appeal of non-fat, low-fat or whole milk beverages.

6. VARIATIONS IN THE COMPOSITION OF MILK PRODUCED IN A HOT, ARID CLIMATE.

Project Number: 491. Funds: Hatch. Personnel: J. W. Stull.

Monthly analysis of milk samples from individual cows of the Guernsey, Holstein and Jersey breeds is being conducted. Approximately 100 animals per

month are being sampled. Determinations for freezing point, butterfat, solids-not-fat and protein are being made. Samples have been stored and work will start soon on analysis of the fatty acid composition of the milk lipides using gas liquid chromatography. The results of 12 months analyses are:

Breed	Freezing Point (-°C)	Butterfat (%)	Solids-not-fat (%)	Protein (%)
Guernsey	0.550	4.60	9.14	3.07
Holstein	0.549	3.58	8.84	2.68
Jersey	0.552	5.44	9.73	3.51

7. THE EFFECT OF ENVIRONMENTAL TEMPERATURE AND LEVELS OF DIETARY ROUGHAGE AND FAT UPON RUMEN, BLOOD AND MILK COMPOSITION AND PHYSIOLOGICAL STRESS.

Project Number: 501. Funds: Hatch. Personnel: W. H. Brown, J. W. Stull, and G. H. Stott.

Lactating cows were placed on experimental diets designed to study the effect of added fat (animal and vegetable) and the level of roughage on the production of milk as affected by winter and summer weather conditions in southern Arizona. Twenty-four cows were used in each section of the experiment (winter and summer). The animals receiving the vegetable fat (cottonseed oil) consistently produced lower amounts of fat and 4% fat corrected milk per day than did those cows receiving either the added animal fat (tallow) or no added fat. There were no significant differences among treatments in level of protein or lactose in the milk or level of glucose in the blood. Level of fat or type of fat had no significant effect on volatile fatty acid levels in the rumen. There was a significantly higher level of acetate produced on the high roughage diets than on the low roughage diets. Milk fat and blood samples were collected and frozen at the end of each experimental period for both the summer and winter trials and are just now being analyzed by gas chromatography for their fatty acid content.

8. ROLE OF THE PARATHYROID GLAND TO CALCIUM MOBILIZATION.

Funds: National Institutes of Health. Personnel: Vearl R. Smith and W. H. Brown.

Mobilization of calcium and phosphorus was compared in normal and thyroparathyroidectomized dairy cows by the intravenous injections of a chelating agent, the disodium salt of ethylendiamintetraacetic acid (Na_2EDTA).

Na_2EDTA was administered slowly, 7 to 9 ml. per minute of a 5% solution, until tetany occurred. Blood samples were drawn before, during and subsequent to a chelation. Tetany usually occurred when the non-chelated blood serum

calcium was reduced from a prechelation level of 11 to 12 mg % to a level of 5 to 6 mg %. Serum calcium usually attained prechelation levels 14 to 18 hours postchelation. Mobilization rates showed considerable variations.

Thyroparathyroidectomy caused a marked lowering of the blood serum calcium. Chelations caused tetany to occur at a higher blood serum calcium level in thyroparathyroidectomized cows than in normal cows and a subsequent shorter time for the calcium to attain prechelation levels.

Bone biopsies were taken from the thoracic vertebrae of normal and thyroparathyroidectomized animals. Bone from the thyroparathyroidectomized animals was more dense than for normal animals as indicated by a greater ash weight.

9. THE RELATIONSHIP OF PHOSPHORUS AND MILK FEVER.

Funds: International Minerals and Chemicals Company. Personnel: G. H. Stott.

Phosphorus supplementation to dairy rations to prevent milk fever has been undergoing tests for the past 18 months. One month after beginning the phosphorous ration feeding, a drop in incidence and severity of milk fever symptoms was observed. Cows calving the last 6 months with their second calf since the beginning of the experiment have shown no milk fever. This is in contrast to the control animals where a 35% incidence has been maintained.

10. ENZYME STUDIES IN RUMINANTS.

Funds: Merck Sharp and Dohme Company. Personnel: W. H. Brown.

Four cows were placed on diets designed to study the effect of added enzymes on the production of volatile fatty acids in the rumen. The cows were treated as follows:

Cow No. 1 - 25 lbs. alfalfa hay + 10 lbs. grain/day
Cow No. 2 - 25 lbs. alfalfa hay + 10 lbs. grain/day + 1.7 grams of agrozyme*/day
Cow No. 3 - 6 lbs. alfalfa hay + 25 lbs. grain/day
Cow No. 4 - 6 lbs. alfalfa hay + 25 lbs. grain/day + 1.7 grams of agrozyme/day

At the end of five weeks on the experimental diets rumen fluid samples were drawn from each cow and aliquot samples were incubated for two hours at a range of pH's from 4.5 to 7.5, with and without added enzyme and with and without added glucose. As this phase has just been completed the incubation samples have not been analyzed at this time. The samples (both before and after incubation) will be analyzed to determine the increase in the various volatile fatty acids.

*Trade name of an enzyme preparation containing lipolytic and proteolytic enzymes produced by Merck and Company.

11. THE ROPY FERMENTATION IN MILK PRODUCED UNDER ARIZONA CONDITIONS.

Funds: Arizona Dairy Technology Society, United Dairymen of Arizona, Arizona Milk Processors. Personnel: F. Eugene Nelson and J. W. Stull.

Work on the project is just getting well underway, since one of the leaders is a new staff member. Of the raw milk samples from producers that have been examined, 16 were nonropy (but with some past history of ropiness in many instances) and 5 were ropy after holding 24 hr. or more at about 75°F. Eight samples of pasteurized products showing ropiness have been examined. Ropy isolates have been obtained from all of the ropy original samples, although a number of the cultures have lost the ropy characteristic when carried in litmus milk in the laboratory. Several of the nonropy samples have yielded ropy isolates. Most of the cultures have many of the characteristics of coliform bacteria of low fermentative power.

12. PARATHYROID ACTIVITY UNDER VARIANT CONDITIONS.

Funds: National Institutes of Health. Personnel: G. H. Stott and Vearl R. Smith.

An investigation of the activity of the parathyroid in disease and normal conditions of calcium and phosphorus metabolism indicates that the parathyroid tissue is highly stimulated in low calcium rickets. However, the large turgid clear cells in the calves with rickets are unlike those in mature animals lactating heavily, or in late stages of gestation where the highly active secreting cells have large granules and vacuoles indicating their activity. In low phosphorus rickets, the tissue of the parathyroid has small cells with pycnotic nuclei suggesting a lack of stimuli. These cytological studies suggest that age is a factor in parathyroid activity or that different hormones are being secreted in mature and young animals. Bioassay studies of parathyroid extracts are being carried out to resolve this question.

Department of
ENTOMOLOGY

1. THE BIOLOGY AND CONTROL OF INSECTS AFFECTING ALFALFA IN ARIZONA.

Project Number: 322. Funds: State and Federal. Personnel: D. M. Tuttle and G. L. Arvizo.

Four insecticide sprays were tested against alfalfa seed pests: malathion, toxaphene + DDT, Dimethoate and Sevin. None of these was satisfactory for lygus bug control. All materials gave fair control for leafhoppers and three cornered alfalfa hoppers with Sevin giving the best results.

Malathion and Guthion sprays gave good control of the Egyptian alfalfa weevil in another test.

In two field tests Kelthane gave excellent control of the two-spotted mite, Tetranychus cinnabarinus (Bois).

At 3 lbs./acre, Dilan apparently controlled lygus bugs in alfalfa during July.

2. BIOLOGY AND CONTROL OF INSECTS AFFECTING COTTON IN ARIZONA.

Project Number: 383. Funds: State and Federal. Personnel: G. P. Wene, D. M. Tuttle, L. W. Sheets (U.S.D.A.).

Hibernating pink bollworm larvae in cotton debris in the soil were destroyed after receiving the equivalent of four weekly irrigations in December. Larvae in unirrigated soil survived at a relatively high rate.

Soil applications of Phorate at the time of planting resulted in seedling cotton plants relatively free from thrips injury and with more and larger leaves than untreated plants, when measured 6 weeks after planting.

The artificial removal of cotton squares in June, to simulate damage of the type produced by lygus bugs, had little influence on yields. Square removal during July decreased yields and also delayed the time of harvest.

A test of treatment schedules against lygus bugs and lepidopterous pests of cotton showed that 7 applications of insecticides made at 10-day intervals, from early July to late August, cost $45 per acre but produced a yield increase worth $137, when compared with untreated plots. The 10-day sequence was equally as effective as a 7-day sequence, and was more effective than a 14-day sequence.

Work was also continued on the field evaluation of new and promising insecticides and combinations against Arizona cotton pests.

3. THE BIOLOGY OF THE KHAPRA BEETLE AND OTHER PESTS OF STORED GRAIN IN DESERT CLIMATES.

Project Number: 389. Funds: Federal and State. Personnel: W. L. Nutting and Research Assistant.

Previous studies have made it clear that the diapause behavior of the khapra beetle and other Trogodema larvae is not governed by a simple food-temperature relationship. Recent work has concentrated on the question of food contamination as a possible factor inducing larval diapause or affecting larval behavior. Ether and water extracts have been made from large quantities of khapra beetle larval frass and tested in the food of Trogodema parabile larvae. There is evidence of a repellent effect from the frass as well as from both extracts, although larval responses are irregular and unpredictable.

The three-year ('56-'59) study on the biology of the khapra beetle under simulated storage conditions was concluded in 1959. Early in 1960 a detailed assessment of grain damage, associated with known insect populations, was made by three different methods and is presented in the report listed below.

Studies on one or more Trogodema species will continue for the purpose of elucidating the factors which induce and break the larval diapause.

Nutting, W. L., 1960. A Study of the Influence of Biological Ecological Factors on Khapra Beetle Populations. Final Report for the period 1 July 1958 to 30 Sept. 1959. U. of A. Agric. Expt. Sta., Dept. Entomology, Tucson, Arizona. (Prepared for the Stored-Product Insects Section, AMS., USDA.)

4. INSECT PARASITES AND PREDATORS OF INSECT PESTS OF ARIZONA CROPS.

Project Number: 404. Funds: State and Federal. Personnel: George D. Butler, Jr., Leader; Floyd G. Werner (Taxonomy), Collaborator.

An insect collecting suction machine was used extensively on various crops during the season. Approximately 100 large samples were collected for further study. Subsamples of specimens from many of these large samples were mounted with special care, sorted, and placed in the insect collection. The large sample of mounted Chalcidoidea on hand from earlier sampling was sorted further. The specimens have provided a good indication of a number of groups which are abundant in the crop areas. A working summary of the species of Chalcidoidea from USDA Mono. 2 recorded from common Arizona crop insect hosts was prepared.

The insect collecting suction machine was used to obtain samples of insects from cotton. It was concluded that the machine with some modifications would be a useful tool to obtain collections of cotton insects.

5. INSECTICIDE RESIDUES: THEIR NATURE AND PERSISTENCE ON ARIZONA CROPS.

Project Number: 416. Funds: State and Federal. Personnel: J. M. Witt, Project Leader; G. F. Bagatella, Research Associate.

Dissipation curves were established for a number of pesticides on several Arizona crops under the climatic conditions of an arid region. Endrin, toxaphene, and Sevin were studied in late applications on lettuce. Sevin and toxaphene were studied on alfalfa. These studies are designed to show the effect of a differential temperature maximum (75° vs. 105°) on dissipation and the effect of growth stage (stubble vs. 6" plant height) on deposit and dissipation. The deposits and residues of DDT applied to cotton with different rates, frequencies, and equipment were studied. Variation of deposit and residues according to leaf location were studied as well as in-plot, between-plot, and sample-size variance. Just beginning, is a cooperative study on the problem pesticide residues in milk with the United Dairymen of Arizona.

6. BIOLOGY AND CONTROL OF ARIZONA VEGETABLE INSECTS.

Project Number: 418. Funds: State. Personnel: P. D. Gerhardt, D. M. Tuttle, Don L. Turley, and George L. Arvizo.

Season-long control of potato psyllids, green peach aphids and thrips on potatoes was accomplished with a single application of Phorate (Thimet) applied at time of planting. Failure to control the potato psyllid was shown to greatly reduce the yield. Untreated and Phorate-treated plots adjacent to each other indicated the protection that the Phorate provided from psyllid attack. Results were obtained from three potato-growing areas on two potato varieties, Red Pontiac and Kennebec.

Of several new insecticides applied to lettuce for looper control, some proved to be highly effective. A spray containing 0.5 lbs. endrin was the most effective material, but the residue problem must be considered. Application of Bacillus thuringiensis dust to lettuce for looper control could only be used later in the season when the looper population was not high.

On sweet corn, two systemic insecticides, Phorate (Thimet) and Di-Syston were applied as soil and foliage treatments for Southwestern corn borer control. Neither insecticide nor method of application proved effective.

Formulations of Bacillus thruingiensis compared favorably with applications of endrin, toxaphene, DDT, and Phosdrin for controlling the cabbage looper on cabbage at Yuma. Detailed field studies were made at Yuma of the seasonal occurrence of insect pests of cantaloupes and insect vectors (particularly the beet leafhopper, green peach aphid and melon aphid) associated with plant diseases of this crop. Nine weekly applications of dimethoate failed to reduce the virus index of treated canteloupe plots as compared to untreated plots.

7. ARIZONA INSECTS OF ECONOMIC IMPORTANCE.

Project Number: 419. Funds: State Research. Personnel: L. A. Carruth, P. D. Gerhardt, D. M. Tuttle, G. D. Butler, Jr., and other staff members.

Three insecticides, Delnav, Guthion and Dibrom, applied with a boom sprayer were compared for the control of citrus thrips. All gave good control

when applied in 100 or 200 gallons of spray mixture. Delnav was also compared with tartar emetic when applied by air, using 20 gallons of spray mixture per acre. Good control of citrus thrips was obtained when applied by air at 1 lb. and 2 lbs. of active Delnav per acre.

Hybrid field corn treated with granular endrin, by air, reduced the number of Southwestern corn borer larvae with an increase in yield of corn. Two applications of granular endrin to fall sweet corn gave good control of Southwestern corn borer and fall armyworm larvae.

At Yuma nine insecticides were tested during May and June for the control of two species of thrips (Chirothrips mexicanus and C. falsus) on Bermudagrass seed crops. A sprayable formulation of Sevin was most effective, sprays containing Diazinon and Trithion were also satisfactory and a Dimethoate spray was promising. Applications containing Dibrom gave erratic control and Malathion sprays were less effective than other formulations tested.

A new species of eriophyid mite, Aceria neocynodonis Kelfer caused serious damage to Bermudagrass lawns at various points in central and southern Arizona in 1960. Symptoms include rosetting of leaves, stunting of internodes and, finally, a browning and dying of the grass. Extreme variations in injury were noted between various Bermudagrass strains under lath house conditions. Mite injury to lawns varied under different conditions of soil moisture and irrigation applications of sulfur dust or of sprays containing Diazinon gave effective mite control.

Rhodesgrass scale was first observed to cause serious injury to Bermudagrass lawns in southern Arizona in 1960. It was particularly abundant in lawns of hybrid Bermudagrass. Sprays containing Diazinon and Korlan were effective against the adult scales although Malathion was less effective when used alone or in a combination with other materials in a spray prepared from a proprietary mixture. Parasites of this pest, obtained from the Texas Agricultural Experiment Station, were released in the Tucson area in 1960 but it now appears doubtful that they have become established.

8. POST-HARVEST DEGRADATION OF INSECTICIDE RESIDUES ON VARIOUS ARIZONA CROPS.

Project Number: Title II 444. Funds: State and Federal. Personnel: J. M. Witt, Project Leader; L. A. Carruth, Coordinator; G. F. Bagatella, Research Associate.

Studies on post-harvest degradation with alfalfa are being continued. It was shown that the high heat utilized in pelleting alfalfa for animal feed does not reduce the level of contamination of at least DDT. Studies at low levels with various other insecticides are continuing. Work with cotton was included because of the importance of some of its by-products. Cotton seed which has been treated with various dosages of DDT and at different growth stages is being processed to determine whether any residues result and the effect of different processing procedures on this residue. The plant parts collected as a by-product of ginning cotton known as "gin trash" which are often used as animal feed and bedding were analyzed, and found to contain far too high amounts of DDT residues to be used in this manner for beef or dairy animals.

9. INSECT PARASITES IN RELATION TO REDUCING CHALCID INJURY TO ALFALFA SEED CROPS.

Project Number: 445. Funds: State and Federal. Personnel: G. D. Butler, Jr.

A suction machine was constructed and evaluated for sampling clover seed chalcids and clover seed chalcid parasites in alfalfa. Samples of chalcids and parasites were collected from replicated experimental plots including five alfalfa varieties. Statistical analysis of the data showed that there was no difference between the number of chalcids collected in the various varieties. The data show the need for more replication and fewer subsamples per plot. Samples of alfalfa pods were collected from which to rear chalcids. Analysis of these data show no significant differences and point out a need for the development of a better criterion for selecting pod samples.

A suction machine was used in large screen cages of plants for alfalfa breeding to evaluate its effectiveness in controlling chalcids. It appeared to be ineffective in reducing the chalcid infestation in the cages.

10. PHYSIOLOGICAL STUDIES OF ARIZONA INSECTS.

Project Number: 461. Funds: State. Personnel: W. L. Nutting.

Work has concentrated on perfecting methods for maintaining large colonies of termites in the laboratory. These insects, with their polymorphic forms, should provide abundant material for a variety of studies on the control of growth, metamorphosis and associated behavior patterns. Pending completion of laboratory facilities, a preliminary analysis has been made of over 150 flight (swarming) records of 16 species of Arizona termites. Some species fly only in winter, others only in summer, while still others may fly during both periods. Many fly only in the evening, others only in the daytime, a few indiscriminately. Rain is also a necessary prerequisite for some, but not for others. Since these flights are so narrowly restricted by various weather conditions, it should be possible to analyze the factors leading to the production of adults and subsequent swarming in the laboratory.

Observations on the winged forms show that dealation can be triggered by one or more stimuli, such as exposure to light, contact with a suitable substrate, a short flight, and association with dealated individuals.

11. TAXONOMY OF ARIZONA ECONOMIC INSECTS.

Project Number: 466. Funds: State. Personnel: F. G. Werner, K. W. Radford (Jan. 1 - June 30), M. L. Noller (Oct. 1 - Dec. 31). (Plus the cooperation of other staff members.)

The major effort of the year has gone into sampling and starting the identification of the parasitic Hymenoptera in the superfamily Chalcidoidea

in samples from crop plants obtained in connection with Hatch Project 404. These samples were taken with a suction device, suitably screened to provide a sample of the very small insects. These and the considerable accumulation of other Chalcidoidea have now been sorted at least as far as the family level. Our interest is primarily in getting an idea of which species are abundant,how abundant they are and what they do. Identification is the first step. This job is far from complete but now is much farther along than it has ever been before. The Proctotrupoid and Bethyloid Hymenoptera have been handled at the same time. These groups are much less extensive. The Bethylidae are being identified by Dr. W. E. Evans. One of the reasons that we expect the work on Chalcidoidea to go slowly is that there are comparatively few specialists and many of these do not willingly undertake identification of specimens for workers outside their own group. We must undertake a major portion of the identification ourselves. The collection occupies 27 drawers, some closely packed.

12. DEVELOPMENT OF REFERENCE COLLECTION OF ARIZONA INSECTS.

Project Number: 467. Funds: State. Personnel: F. G. Werner, K. W. Radford (Jan. 1 - June 30), M. L. Noller (Oct. 1 - Dec. 31), J. C. Bequaert (Sept. 15 - Dec. 31). (Plus the cooperation of other staff members.)

The major accomplishment of the year was the expansion and start on identification of the reference collection in the wasp superfamily Chalcidoidea. Most of the members of this group are parasitic on other insects; a few are of direct importance to man as crop pests, since the larvae eat alfalfa seed, bore into grass stems, etc. This activity is reported more completely under State Project 466.

Dr. J. C. Bequaert has started working on the collection of bees. While many species have been identified, there remain many genera for which we have no identified specimens at all. Dr. Bequaert is working with these and assembling the literature it will take to permit accurate identification of our species. He is also identifying our insects in the various other groups which have been of particular interest to him in the past.

Much of the addition of specimens to the collection during the past year has been in the groups of parasitic insects. Progress on the preparation of the large samples of insects from Sonora and Baja California has been slow. However, the employment of Miss Noller as an assistant should speed up the preparation of specimens. She has started with the parasitic groups and has sorted through masses of specimens for additions to the collection, mounted and labeled them. These activities are time-consuming, but necessary for the development of the collection in this area. The species are almost all too small to be recognized in the field, and many are too small to place even to major category unless they are examined at fairly high magnification.

The insect collection continues to become more representative of the fauna of the state of Arizona. New Identifications have been added in many parts of the collection, but particularly in the parasitic Hymenoptera.

School of
HOME ECONOMICS

1. THE RELATION OF WARM CLIMATE TO BASAL METABOLISM AND BLOOD CHOLESTEROL.

Project Number: 420 (W-44). Funds: Regional Research and State.
Personnel: Ethel M. Thompson and Mary Ann Kight.

Serum weekly total cholesterol, monthly hemoglobin concentrations and seasonal blood pressures of 12 postmen have been shown to have no correlation with change in season. Conversely, thyroid activity as measured by seasonal basal metabolism and monthly serum protein-bound iodine was demonstrated to be significantly lower in summer than in winter.

Individual means of fasting total cholesterol concentration from May, 1959, to September,1961, incl., were: 8 subjects, 236-286 mg%, C.V. 9-13%; 2, 215 and 221 mg%, C.V. 12 and 13%; 2, 179 and 180 mg%, C.V., 8 and 9%. Basal metabolism determinations for the group averaged 38.1 (32.4 - 46.4) calories/m^2/hr with a deviation of -0.6 (-8.0 to +15.4)% from the Mayo Foundation standards in winter and 35.9 (32.4 - 37.8) calories/m^2/hr and -5.9 (-14.7 to -0.2)% deviation in summer. Protein-bound iodine values for all subjects were between 2.7 and 6.4 mcgm% from July to October, incl., and 6.2 and 10.4 mcgm% in January and February. Nine per cent more calories were consumed in winter than spring or summer and 50% more ascorbic acid in summer than the other two seasons. There were no significant differences in the other nutrients. Saturated fatty acids were estimated to average 41, 42, and 44%, resp., in spring, summer, and winter. Final physical examinations, including gross endocrinopathy and exercise tests including two electrocardiograms are now being completed and will be evaluated.

2. INTERIOR AND EXTERIOR TREATMENTS TO MODIFY BRIGHTNESS OF NATURAL LIGHT TO THE LEVEL OF HUMAN COMFORT.

Project Number: 482 (W-69). Funds: Regional Research and State.
Personnel: Faye C. Jones.

A comparative heat absorption test was made of 24 colors to determine the influence of the attributes of hue, saturation and lightness on heat absorption. The aspect of hue was completed and some testing was done on other attributes. Additional testing will be needed to find the influence of the other attributes. Approximately 115 different exterior building materials and surface finishes were prepared as test panels for a five year duration weathering test to determine the influence of weathering on the reflectivity of those materials. A color preference rating was conducted in five sampling areas to determine preference of the public for colors. Their selections provide a basic group of colors for various aspects of the experimental work. Experimental work to determine human tolerance for reflected lightness--a quantitative measurement is underway. Test panels are being prepared for a comparative temperature study of various colors of roof toppings. The work with these panels will consist of a comparative temperature

rise study and color retention test. The toppings consist of three basic materials and are the type which may be applied to either pea gravel or asphalt shingle roofs. The results of this project will provide basic planning data needed to improve thermal and visual environments of houses and other structures. The information will be applicable to both new and existing buildings. There are potential economic gains.

3. THE EFFECT OF FEEDING GRADED LEVELS OF DIETARY FAT ON CONCENTRATION OF SERUM CHOLESTEROL AND BETA-LIPOPROTEINS AND LESION FORMATION IN THE CHICK.

Project Number: 510. Funds: Hatch and State. Personnel: Project Leader, Dr. Ethel M. Thompson; Research Associate, Mary Ann Kight and Technical Assistant, Mary H. Bradley.

Techniques are being developed for collection and analysis of blood samples by wing puncture. Measurements are being made of serum total cholesterol and lipoprotein concentrations beginning with week-old chicks maintained on the customary dietary containing 3% fat. Total cholesterol is measured by Adamson's unpublished micromodification of the method of Pearson, Stern and McGavack (Anal. Chem. 25:813, 1953) and lipoprotein by a modification of the paper electrophoresis method of Jencks, Durrum and Jetton (J. Clin. Invest. 34:1437, 1955). Equipment acquired includes a Petersime Brood Unit, Spinco Model Duostat, Analytrol, Pyro-Magnestir, and 2 Durrum cells. Measurement of serum proteins will be made concurrently with lipoproteins by paper electrophoresis.

4. ROLE MODIFICATIONS AND ADJUSTMENT OF THE PHYSICALLY DISABLED MALE WITH IMPLICATIONS FOR COUNSELING.

Project Number: 515 (205-170). Funds: State, and OVR Grant. Personnel: Victor A. Christopherson and John A. Haberland.

A pilot questionnaire study was conducted in the spring of 1960. This phase of the study had as its purposes: (1) to locate a sizable group of physically disabled males; (2) to explore the nature and adequacy of counseling the subjects received relevant to their occupational and medical status. This questionnaire was sent to 368 disabled men whose programs of rehabilitation had been completed during 1958-59. Of the 368 questionnaires, 172, or 46% were returned. Data were provided concerning the subjects' estimates of the assistance rendered by vocational counseling, job satisfaction, adequacy of counselor, interim jobs, medical services, and relation of handicap to job.

Based upon the indications of this pilot study and prior theoretical considerations, the present project was described and submitted. The directory of subjects provided by the pilot study was expanded and refined, interview instruments were constructed, and standardized tests were selected. The project was approved by the Office of Vocational Rehabilitation, Health, Education and Welfare, to begin February 2, 1961, and to last until January 31, 1962.

Constructive role modifications with pattern potential as well as the aetiology of negative modifications should provide rehabilitation information that will help restore more quickly and completely disabled men to productive work. It is estimated that this will frequently involve adjustment from agriculture to non-agricultural work as a result of physical injury. As yet there is a dearth of information concerning role modifications of the physically handicapped.

5. OWNERSHIP OF MAJOR HOUSEHOLD EQUIPMENT BY ARIZONA FAMILIES AND METHODS OF PURCHASING AND FINANCING SUCH EQUIPMENT.

Funds: State. Personnel: Dr. Alida Hotchkiss.

A mail questionnaire dealing with items of household equipment owned by families has been completed, and the data is now being coded for tabulation. It is planned that families who have purchased a freezer or a washer recently will be interviewed personally with respect to their methods of purchasing, planning before purchase, and methods of financing these two items of equipment.

Department of
HORTICULTURE

1. BREEDING AND IMPROVEMENT OF MELON VARIETIES.

Project Number: 295. Funds: Hatch and State. Personnel: R. E. Foster, E. L. Murdock, H. Williamson, (H. Dennis).

Progeny evaluated in observation trials at Yuma and Mesa, Arizona. Stocks rated for both crown-blight resistance and high fruit quality. On basis of these trials 40 lines selected which appeared to have both characteristics to valuable degree. These stocks planted in fall breeding plots and self-polinations made on each individual plant. Mass combinations of this seed used in replicated variety trials to determine value in comparison with standard varieties. Individual plots of "self" seed will permit elimination of less valuable progeny if mass increase is desired following trial results. Large number of back-crosses and out-crosses made involving crown-blight resistant and high fruit quality stocks. Progress being made in improving quality in crown-blight resistant material. Assay of breeding lines for relative susceptibility to watermelon mosaic continues. Some stocks found showing very low incidence of virus development even under severe test conditions.

Program seems close to obtaining new cantaloup variety having high fruit quality and measurable degree of crown-blight resistance plus adequate yield potential. Breeding stock obtained for development of watermelon mosaic resistant strain.

2. MELON PHYSIOLOGY - FACTORS AFFECTING THE QUALITY OF ARIZONA MELONS.

Project Number: 296. Funds: Hatch and State. Personnel: W. D. Pew, L. Burkhart, J. H. Parks, G. C. Sharples, E. Elson.

Results from this test show that in certain cases wide differences in number of irrigations produce about identical yields. Data also indicates that timing, rather than frequency, appears to be most important in determining proper irrigation of cantaloups. Further, cantaloup plants have a remarkable recovery capacity after being exposed to slowly developed severe drought conditions. Excessive soil moisture during the early developmental period of the cantaloup plants make them vulnerable to rapid collapse if adequate moisture is not maintained during later growth periods. Excessive soil moisture (reduced soil air) appears to markedly reduce the amount of deep as well as extensive roots and thus minimize the plant's capacity to obtain water. Excessively high soil moisture levels reduce yields. Relations between moisture stress and blossom formation, percentage of male and female blossoms and amount of blossom drop has been relatively inconsistent. Studies are being conducted to relate growth and yield of cantaloups grown over a wide range of soil nitrogen availability to chemical composition of foliage. An experiment in 1960 plus re-evaluation of the 1959 experiment showed a strong relationship between nitrate content of leaves and petioles sampled at thinning time and yield of marketable melons. Total nitrogen in tissues was in general related

to yield, but the scale length of values is short and less adapted to interpolation.

Data from this test provides information for a better understanding of the proper irrigation practices to produce the best and most economical yields. This information will give commercial growers a background to enable them to produce greater yields of better quality melons and reduce water consumption for a reduction in total costs. Findings may be useful as a basis to develop methods of assessing the nutrient status of cantaloups by chemical analysis in early stages of growth. Such analyses would serve as guides to subsequent fertilization and to predict crop response in advance.

3. LETTUCE BREEDING IN ARIZONA.

Project Number: 297. Funds: Hatch and State. Personnel: R. E. Foster, L. Burkhart, P. M. Bessey, E. L. Murdock, H. Williamson.

Seed of new tip-burn resistant lettuce variety "Arizona Sunbright" released to interested seed companies. Necessary for companies to "clean up" seed-borne mosaic and then increase. First commercial seed may be available 1962. Work continued in selecting additional strain for tip-burn resistance as well as improve Arizona Sunbright. Progress noted in reducing susceptibility to Big Vein by field selection. Plastic greenhouse constructed at Mesa to enable continuing program on development of many lettuce strains immune to downy mildew. Environmental control plus gibberellic acid used to speed program to several generations per year in backcross method. Resistance to pink rib and rib discoloration also under selection in extensive field plantings. Preliminary tests indicate selections may be made among seedlings grown under controlled environment thereby increasing scope of work. Other valuable characters in lettuce under extensive study.

Major diseases of Arizona lettuce gradually to be reduced in importance as progress made in program. Tip burn and downy mildew soon to be controlled with considerable promise evident for control of big vein; other diseases more difficult.

4. LETTUCE PHYSIOLOGY - CULTURAL FACTORS AFFECTING THE PRODUCTION OF LETTUCE IN ARIZONA.

Project Number: 298. Funds: Hatch and State. Personnel: W. D. Pew, James H. Park, L. Burkhart, G. C. Sharples.

Results of this year's study are somewhat different than found in earlier work dealing with irrigation of lettuce. The chief difference was the fact that the highest moisture level produced the best yields. The greatest margin in production occurred in the two-dozen size group rather than the one and one-half and two and one-half dozen size. The yields from the medium wet treatment and the treatments involving changes of moisture level (1. from the high moisture level early to a low moisture level late in the season and 2. from a low moisture level early to a high moisture level late) were approximately the

same and were significantly lower than for the very wet treatment. The yield from the uniformly dry treatment was significantly poorer than all other treatments. However, with this relatively limited amount of water, the yield was not as poor as might have been expected. The important findings with this treatment were the noticeable delay in maturity and the marked reduction in head size for the majority of the plants.

The findings in this test are too inconclusive to provide a direct contribution at the present. However, when more data are accumulated it will provide the growers with a better understanding of a proper way to irrigate for maximum yield and best quality.

5. FACTORS AFFECTING THE PRODUCTION OF CITRUS IN ARIZONA.

Project Nmmber: 299. Funds: Hatch and State. Personnel: R. H. Hilgeman, D. R. Rodney, L. Burkhart, G. C. Sharples, C. Everling, T. Hales, J. B. Carpenter, J. R. Furr.

SALT RIVER VALLEY: Varieties: Budwood from 9 new varieties were introduced through cooperation of ARS. Rootstock: Yields on Lisbon lemon planted in '52 to date show no significant differences between Rough lemon (18 boxes), Sacaton citrumelo (17.5 boxes), Oklawaha sour (16.5 boxes), Rangpur lime (16.5 boxes) and Florida sour (15.0). Troyer citrange and Koethen sweet were slightly lower, Wilking mandarin much lower. Tillage tests suggest that the harmful effects of bermuda sod are decreasing as the trees become larger. Urea sprays at .6# N/tree have produced grapefruit yields equal to those from 2# N/tree in the soil. Harvest of grapefruit prior to bloom continued to maintain highest yields, but early harvest of Valencia orange has been inconclusive after 2 years. Pruning moderately failed to reduce yield, or influence size or grade the first year. Gibberellic acid at 20 or 50 ppm. applied before bloom reduced yields, but did not defoliate trees. YUMA: Fertility: Valencia Orange Trees (10 years old) have been given differential rates of nitrogen fertilizer since three years of age, including 1, 2, 3, and 4 pounds of nitrogen per tree per year. For the last four years, there has also been an irrigation differential. In the 1959-60 season (1959 bloom year), the rates of nitrogen applied had no significant effect on the number of fruit per tree or fruit size. There was greater production in pounds per tree on the wet irrigation treatment than on the dry treatment. YUMA Rootstocks: Lisbon lemon trees on eight different rootstocks were planted in 1952. The trees on rough lemon and Rangpur lime have consistently been the most vigorous and productive. The trees on Rough lemon rootstock had the highest yield(5.8 boxes per tree) and it was significantly greater than the others except Rangpur lime (4.0 boxes per tree), Rangpur lime yields were significantly greater than that of the other stocks except Poncan (2.1 boxes per tree).

Salt River Valley: Chopping cover crops in summer which has shown to be cheaper and as effective as disking was adopted on about 1000 acres in 1960. Non-tillage, is now in use on about 900 acres. Nucellar navel budwood is now used by all nurseries. YUMA Fertility: Production is reduced by an irrigation schedule such as the dry treatment (irrigated when moisture tension reaches 60 to 70 centibars) which causes fruit enlargement to cease between irrigations.

For trees of this age growing under these conditions, one pound of nitrogen per tree per year is apparently sufficient. YUMA Rootstocks: The trees on Poncan and Troyer citrange have performed satisfactorily and may prove to serve some purpose under certain conditions even though their yields at present are below those of Rough lemon and Rangpur lime.

6. SHIPPING QUALITY AND POSTHARVEST FACTORS AFFECTING THE MARKETABILITY OF ARIZONA GROWN VEGETABLES.

Project Number: 308. Funds: Hatch and State. Personnel: P. M. Bessey, L. Burkhart, G. C. Sharples, R. E. Foster, W. P. Bemis, W. D. Pew.

Work was continued in plotting senescence or aging patterns of lettuce under varying postharvest conditions. N^6 benzyladenine sprays at 10 ppm applied to lettuce in the field and at varying postharvest times increased storage life markedly. Trimming of lettuce to retail condition and film wrapping tests, both conducted under simulated shipping point-transit conditions, clearly demonstrated that only excellent quality lettuce may be satisfactorily handled in this manner. Potato quality (Specific gravity and defects) was checked in a survey of the two major production areas (Yuma and Queen Creek) with additional samples obtained from most other areas by cooperating inspectors of the Arizona Fresh Fruit and Vegetable Standardization Service. Quality of processing types, mostly Kennebec variety, were found to be far better than predicted. In specific gravity they were equal or superior to competitive sources anywhere else in the country. Fresh market types, mostly Red Pontiacs, are under extreme market pressures for early harvests which result in immature tubers with low solids, excessive feathering and scuffing in harvest and occasional tuber collapse while in transit. Evidence of high temperature tuber damage was fairly common. With melons, work was done on the effects of harvest maturity and storage atmosphere on resulting quality. Several consistent and recognizable flavor components were distinguished and evaluated for intensity and effect on total flavor. Studies were made of the distribution and activity of polyphenol oxidase and peroxidase in head lettuce leaves of different ages, as an aid to sampling for future studies. Exploratory studies are in progress of the seasonal variations of enzyme activity in head lettuce and several leaf types. G.L.659 (head) showed a decrease in phenol-oxidase and a marked increase in peroxidase during the heading stage in January. Changes during heading at other seasons are being studied. These changes may be associated with the appearance of pink rib and rib-discolcration in the leaves.

N^6 benzyladenine sprays at 10 ppm will extend lettuce market life reducing its perishability. Shipping point weight, reduction of lettuce by retail trimming results in satisfactory quality at retail only when top quality lettuce is used initially. Arizona spring-grown Kennebec potatoes for processing were found to be equal to or better than competitive potatoes. First steps were made in developing a flavor profile for cantaloups to aid in selecting the best harvest and storage conditions. Findings may be an aid to understanding the underlying causes of pink rib and rib-discoloration and suggest means of reducing or eliminating damage which is significant in some years.

7. RESPONSE OF CITRUS TREES TO SOIL MOISTURE; MOVEMENT OF SOIL MOISTURE IN THE ROOT ZONE.

Project Number: 371. Funds: Hatch and State. Personnel: R. H. Hilgeman, C. R. Everling.

Under favorable fruit set conditions in 1959 yields reflected the size of trees which had previously been closely correlated with the amount of water applied. Fruit growth in 1960 revealed that after 11 years of continuously low soil moisture, the root-top ratio has apparently changed so that fruit growth did not reflect soil moisture depletion as it did in the first 3 years of the test. Under high transpiration conditions, internal water stress increased with low soil moisture; however, when trees grown under low soil moisture had ample soil moisture, soil moisture stresses were less than in trees grown with continuous ample water. Transpiration from citrus leaves apparently decreases with age of leaf. Young trees mulched with 4 inches of gin trash required only 60 percent as much water as bare soil trees to maintain approximately equal suction forces in the soil in the tree ball. Water lost from the upper 24 inches between 6/18 and 7/18 amounted to 7.1 inches in bare soil and 3.8 inches in mulched soil.

Trees adapt to unfavorable soil moisture conditions, so fruit measurements may result in erroneous conclusions. Irrigation when soil suction in the major root zone is 50 centibars has produced maximum tree growth with gradual yield increase. Mulches reduce evaporation losses so that irrigation intervals can be increased.

8. CONTROL OF WEEDS IN LETTUCE AND CANTALOUPS.

Project Number: 374. Funds: Hatch and State. Personnel: W. D. Pew, J. H. Parks, H. F. Arle.

Improving weed control activity is an essential step in an herbicide evaluation program. With lettuce, a combination of specific older herbicides was found to be very effective in this test. A combination of CDEC at 2 pounds per acre and CIPC at 2 pounds per acre gave outstanding results in controlling broadleaf weeds as well as many grasses that are troublesome in lettuce production. The reduced amount of herbicide and the improved weed-kill capacity makes this treatment very interesting commercially. Using either of these materials at 5 pounds per acre was less effective than the combination. Zytron, an herbicide that has looked very promising with cantaloups, when applied at 15 pounds per acre proved very damaging to lettuce seedlings. The adverse effect of this chemical may have been directly associated with the amount of herbicide rather than the material itself. The combination of CDEC and F734, both at 2 pounds per acre, proved ineffective and was toxic to the crop plant. Sprinkling (simulated rainfall), immediately following an application of CDEC, caused a reduction in yield. To provide a chemical that will control weeds more effectively and one that will control both broadleaf weeds and grasses is the aim of this test. Several new materials have been evaluated. These chemicals have been checked against Alanap 3, the currently recommended herbicide. Of the new chemicals in this test, two appeared to be good enough

to be evaluated a second year. Zytron at 15 pounds per acre gave the best weed control and did not reduce yields. It was relatively effective against broadleaf weeds as well as grasses. Monsanto 10543 was considered second-best in weed control, but this material caused some chlorosis in the seedling plants. The chlorosis did not persist long and did not markedly reduce yields. Dicryl gave unsatisfactory results because of its crop-plant toxicity. As demonstrated in earlier tests, Alanap 3 at 9 pounds per acre, applied pre-emergence, was better than this material applied post-emergence. Yield differences were not large, however, and either timing appears quite effective.

The combination of the two somewhat select herbicides known as CDEC and CIPC produced very interesting and satisfactory results and may provide an excellent commercial method of controlling weeds in lettuce, if the results from the next two years' test are as effective as the one just completed. This combination seems to increase weed kill and thus could reduce the need of costly hand weeding. Data collected in this test indicate that a new material, Zytron shows considerable promise because it is relatively effective in controlling both broadleaf weeds and grasses, whereas Alanap 3 is largely effective against broadleaf weeds. Alanap 3 is currently being used commercially with good success except on grasses. The use of Zytron, if proven consistent, may cut weeding costs for the farmer.

9. PROTECTION OF CITRUS TREES & FRUIT FROM FREEZING INJURY.

Project Number: 384. Funds: Hatch and State. Personnel: R. H. Hilgeman, C. R. Everling.

In 1959-60 wind machines were operated for a total of 46 1/2 hours on 9 nights when control minimum temperatures ranged from 28° to 22.3°F. Wind machines on 3 ten-acre units provided data on the interactions between machines. With a strong drift from the dual fan machine downwind toward a single fan machine gains were approximately equal in both locations. A cold area which changed with different wind drift patterns developed in the zone between the three machines on several nights. Temperature gains were always closely related to the amount of inversion. On two nights when inversion between 5 and 50 feet was less than 4° supplemental heat was used but unstable conditions precluded obtaining accurate data on additional temperature increases.

While temperatures decreased with distance from the machines, the three machines appeared to produce a higher over-all increase over the thirty acre tract than was expected from previous data from one machine. With average inversion on 9 nights of 5.4°F. the following increases occurred: 16' fan dual, 2.7°; 13' propeller dual, 2.4°; 16' ground single, 2.2°. Maximum gains averaged 4.1°.

Wind machine efficiency appears to improve when several machines operate in an area. When inversion is low supplemental heat must be provided. Slight injury to Valencia fruit but none to leaves and twigs occurred with 6 hours duration below 26° with a minimum of 22.3 on February 25.

10. FACTORS AFFECTING THE PRODUCTION OF PECANS IN ARIZONA.

Project Number: 398. Funds: Hatch and State. Personnel: J. R. Kuykendall, S. Fazio, J. Folkner, K. C. Hamilton, Leonard Erie, USDA ARS.

Yield Data: Yield of 1078 lbs. of husked Burkett nuts was lower than 1124 lbs. in 1959. 52% of Mahan trees were "on crop" year yielding 1024 lbs. of husked nuts compared with 464 lbs. in 1959. Alternate Bearing Habit: Re-examination of individual tree yields for 1957-60 indicates 65% of Mahan trees with alternate bearing habit, but only 11% of Burkett trees. Stick-Tight Nuts and Soil Moisture: Data for "on crop" Mahan trees showed 34% stick-tight nuts on "dry" plots compared with 44% stick-tight nuts from "wet" plots. Leaching: Two plots (4 trees each) in each of the Mahan and Burkett blocks were deep-plowed and leached in May, 1960. Data from soil samples taken prior to and after leaching indicated variable reduction in TSS around individual trees. No effect of leaching was noted in yield or % stick-tight nuts.

Additional yield data has helped to clarify alternate bearing pattern on certain individual trees. This will serve as basis for evaluating leaching, fertilizer and weed control experiments now under way. There is an indication that the high incidence of stick-tight nuts on the Mahan variety may be associated with soil moisture management.

11. LEMON PRODUCTION IMPROVEMENT IN ARIZONA.

Project Number: 405. Funds: Hatch and State. Personnel: D. R. Rodney, J. R. Kuykendall, G. C. Sharples, T. Hales, R. E. Grounds, H. F. Tate, F. Turner, H. F. Kreizinger, Charles Bowers.

Lemon Pruning Effects

Lisbon lemon trees planted in 1955 have been pruned annually since 1958 according to five different methods. In 1960, the yields were light for trees of this age, but yields of the control trees were consistently greater than those of the other treatments. The 13 control trees averaged 0.72 boxes (approx. 144 fruit) per tree and the lowest yielding treatment averaged 0.29 boxes (approx. 58 fruit) per tree.

Lemon Fertilizer Treatments

Lisbon lemon trees, 7 years of age, growing on unsilted superstition sand have annually received differential treatments including three rates of nitrogen, two rates of phosphate and two rates of manure. There have consistently been yield responses to the applications of phosphate in addition to the highest rate of nitrogen and to manure applications in addition to all rates of nitrogen. Leaf analyses showed the phosphorous content of the leaves to be inversely related to the amount of nitrogen applied and unaffected by the phosphate applications. The nitrogen concentration in the leaves, however, was unrelated to the rates of nitrogen applied and was low in all samples when judged by the standards established for oranges. Soil samples, analyzed

by members of the Dept. of Agricultural Chemistry and Soils, showed that phosphorous moved laterally 24 inches and vertically 36 inches from the point of application.

Since these trees are just coming into production, it is not surprising that pruning has reduced yields. It remains to be seen whether pruning in these early years will build a frame work that will result in greater yields in the future.

As a result of having analyses of leaf samples collected in alternate months throughout the year, it is evident that the nitrogen content of lemon leaves drops sharply in the late summer except in those trees receiving applications of steer manure. It is also apparent that making nitrogen available over a longer period (as in the breakdown of manure) is more effective than applying larger amounts per application.

12. TABLE GRAPE QUALITY.

Project Number: 343. Funds: State. Personnel: J. R. Kuykendall, R. H. Hilgeman, G. C. Sharples, S. Fazio, L. F. True, H. F. Tate, C. E. Everling, H. J. Phillips.

Continued studies show that market quality of Cardinal grape clusters is greatly improved by removal just before blossoming of 1 cm of the inflorescence apex. Yield of No. 1 grade was increased 115%, clusters ripened earlier and were more compact. Culls were reduced by 47%.

Thompson seedless grapevines sprayed with 40 ppm gibberellin and girdled at the normal time produced the largest berries of all treatments. Both treatments tend to reduce sugar content, however. Delaying the girdling of GA treated vines until 2 weeks before harvest tended to reduce the berry size response somewhat, but greatly increased the sugar content.

The 1960 grape season was moderately late with full harvest operations starting June 20. 498 samples of Cardinal grapes were tested between June 16 and July 9. Samples passing 15% solids are as follows: early (June 16-23) 85%; mid-season (June 24 to July 3) 97%; late (July 4-9) 100%. Total soluble solids and acid were slightly higher than in '59. A summary of data obtained in 8 years between '51 and '60 show 90% passed 15% solids; 68% passed 16% solids; 47% passed 17% solids.

In 1952, '55, '56 and '58, when solids were below average, blossoming was late and average maximum temperatures during the 30 days after bloom were above 91°. Highest solids were associated with early bloom and temperatures below 89°. Maturity standard recommendations were made to growers.

Thompson seedless grapes were tested July 2 to 14 and 184 samples. Percentages of samples passing different soluble solids contents follow: 97% passed 15%; 82% passed 16%; 65% passed 17%.

Immediate financial gains to the individual grower can be considerable through premium prices paid for high quality fruit, but they could be nullified

through widespread use of such techniques. Long-term benefits to the industry and public as a whole will result, however, through practices which tend to raise fruit quality.

In 1960 the grape industry requested a grape maturity law which is being established by the Fruit and Vegetable Standardization Service. Data from this project was used to set a 15% T.S.S. minimum for Cardinals and a 16% T.S.S. for Thompson seedless. Federal grade standards for Arizona Cardinals have been reduced to 15% T.S.S.

13. DECIDUOUS FRUIT VARIETIES.

Project Number: 344. Funds: State. Personnel: J. R. Kuykendall, P. M. Bessey, L. Burkhart, J. S. Folkner.

An examination of daily temperature records for three years has indicated a possible relationship between high afternoon temperatures during the winter months and delayed foliation of stone fruit trees in the Salt River Valley. In two winters preceding years in which foliation of stone fruit trees was very late, the number of hours above 60°F. was greater than the accumulated number of hours below 45°F.

Chemical Thinning of Peaches: See Report for State Research 352 - GROWTH REGULATORS.

Information on the possible discompensating effect of large fluctuations in day-night winter temperatures is necessary in evaluating suitability of stone fruits for desert conditions.

14. VEGETABLE DIVERSIFICATION IN ARIZONA.

Project Number: 345. Funds: State. Personnel: W. P. Bemis, P. M. Bessey, H. Williamson, R. E. Foster, J. H. Parks, W. D. Pew, J. M. Nelson.

Summarization and tabulation of temperature data for ten stations in southern Arizona. Being prepared for distribution to interested persons.

Tomato production study in Yuma Valley - being prepared in mimeograph form.

Winter tomato variety trial under plastic greenhouse, Tucson.

Miscellaneous vegetable research under plastic greenhouse, Tucson.

(1) Temperature data to be used as a tool for prediction of temperatures based on probability levels. (2) Results of Tomato Variety Trial Spacing, date of planting, etc. for the Yuma Valley, 1960 will be available to persons contemplating commercial production in that area. (3) The limited tomato trial under plastic indicate that significant varietal differences exist and that varieties specifically adapted to plastic production are needed. The

varieties tested yielded from 29.7 to 48.7 tons per acre equivalent during the December-January harvest period.

15. PROPAGATION OF HORTICULTURAL MATERIALS.

Project Number: 349. Funds: State. Personnel: S. Fazio, J. R. Kuykendall.

Propagation of Eucalyptus trees by stem cuttings has proved feasible under mist with the use of concentrated growth regulators. Certain species have rooted as high as 60% in preliminary tests conducted during the past year. Wounding of firmwood and hardwood has increased amount of rooting over non-wounded cuttings. Cuttings are being made at various times of the year to determine whether any one period is superior to another.

Eucalyptus propagated vegetatively are uniform in their characteristics when compared to those grown from seed. Superior plants grown from seed will be selected as the clone for increasing these individual plants. Many of our Eucalyptus grown from seed are spindly types and require constant pruning to reduce their height.

16. LANDSCAPE MATERIALS TESTING.

Project Number: 350. Funds: State. Personnel: L. Burkhart, J. S. Folkner, R. Charles, R. Jones.

Several species of landscape plant materials have been introduced and established on The University of Arizona campus and at Branch Agricultural Experiment Station sites of the state, and these have proven well adapted for landscape use in southern Arizona. Outstanding among these are: Rhus lancea, Pistachio chinensis, and related species, Cercidium floridum, and more recently Lantana velutina and other species from collections made in Mexico.

In the establishment of a rose test garden in cooperation with the City of Tucson Parks Division, there have been assembled during the year 114 varieties including hybrid teas, floribundas, tree roses and climbers. 600 roses have been placed in experimental plots where they are to be subjected to cultural differential treatments.

During the years 1960 and 1961 considerable advancement has been made with respect to roadside landscape plantings. Five new species are being tested in southern Arizona at the present time. In addition to the species being tested, tests are being conducted to determine the proper basin sizes, proper watering practices, proper pruning methods for pre-planting and desirable mulches. Propagation studies are being done with native desert materials. These tests are being done with seed, branch cuttings, and root cuttings. The desired information will lead to a nursery to supply the state's plant needs. Ground cover species are being used to aid in erosion control. Ground cover species include the grasses as well as the flowering species. Plant observations are being made on all species used in the testing program. A listing of desirable plants for traffic interchanges, drainage banks, rest areas, etc. will be

available at the conclusion of these tests.

A major difficulty experienced with overseeding a Bermuda grass turf with Annual Rye grass is the rate of recovery of the Bermuda in the spring. An overseeding project was initiated October 1960 to determine if some other grass could replace or complement Rye grass, thereby offer less competition with Bermuda. Another testing program was also initiated October 1960 to determine if any of several Blue Grasses could be adapted for Arizona use.

The landscape nursery trade and other interests are currently using the information developed in this project. This is aiding Arizona people in urban and rural areas.

17. GROWTH REGULATORS.

Project Number: 352. Funds: State. Personnel: J. R. Kuykendall, J. Folkner, D. R. Rodney, T. A. Hales.

Chemical Thinning of Peaches: An experiment involving 2 chemicals (NPA and 3-CP), three times of application and four varieties was conducted in Cochise County. Extreme variability of % fruit-drop data precluded establishing any significant differences between treatments. Random tagging of branches for fruit-drop counts has been established as the main source of variability-assumption is made that shoots of the same morphological type must be used in order to obtain consistent and reliable fruit-drop counts.

Fruit-set on Tangerines: Gibberellin sprays applied at petal-fall resulted in better set and yield. Applications of 2,4, 5-TP tended to reduce amount of June-drop.

Establishment of sources of variability will enable the use of greater precision in chemical thinning experiments. Need for more critical classification of flowering and fruiting patterns for varieties has been indicated.

Department of
PLANT BREEDING

1. A STUDY OF THE INHERITANCE OF FIBER QUALITIES IN SELFED LINES OF UPLAND COTTON.

Project Number: 47. Funds: Hatch and State. Personnel: E. H. Pressley, W. D. Fisher, C. D. Manderscheid, and Jean L. Dykeman.

The three subfamilies of 44-10 from which Breeder's seed are now being obtained were tested again in 1960. Registered and foundation seed were included as checks along with California 4-42. Results obtained at the Cotton Research Center are shown below.

TABLE 1

Family or Variety	Yield-% of Reg 44	% Lint	Length UHM	Fiber Strength	Fiber Fineness
A-44 Reg.	100.0	35.5	1.09	3.56	4.57
4-42	101.1	37.5	1.08	3.99	4.70
A 44-10-1	101.4	35.8	1.12	3.47	4.66
A 44-10-17	104.7	36.2	1.11	3.52	4.67
A 44-10-16	105.1	36.0	1.09	3.46	4.53

While the average yield of the new strains was about 4% higher than that of registered A 44, the difference was not significant. They were, however, about 1/32 of an inch longer. The spinning performance of A 44-10 is shown in Table 3. One acre was planted at Iguala, Mexico, with selfed seed of the A 44-10 strains in the fall of 1960. This should make possible a rapid build-up of registered and certified seed.

In September of 1960, a male sterile plant was found in a field of A44 planted with Breeder's seed. The male sterility is due to the failure of anther development in the flowers. The filaments in some cases have enlarged tips which resemble rudimentary anthers, but when examined under a microscope no sporogenous tissue could be found. The female part of the flower is fertile and develops normally when pollen from another source is supplied. This plant was brought into the greenhouse and eight bolls produced during the winter using normal A 44 plants as a source of pollen. The seed thus obtained will be planted in the field to initiate a study of the inheritance of this male sterile factor.

Nineteen F_7 strains were grown in an advanced strain test at the Cotton Research Center. Included in the test were A 44-10, Deltapine Smoothleaf, and four strains from California. There was no significant difference in the yield of A 44-10, Deltapine Smoothleaf, and nine of the F_7 strains. Yields and

laboratory data are shown in Table 2 below:

TABLE 2

Strain No.	Lint per Acre	% of A-44	% Lint*	Length UHM	Fiber Strength	Fiber Fineness
227-12-1-4-4	1390	107.6	35.4	1.16	3.89	4.83
Deltapine S L	1372	106.2	37.6	1.07	3.18	5.18
228-1-3-2-1	1370	106.0	36.6	1.13	3.66	4.72
209-4-4-2-5	1358	105.1	37.6	1.14	3.78	4.79
227-12-1-4-11	1357	105.0	36.5	1.12	3.74	4.95
221-7-3-5-5	1337	103.5	36.1	1.18	3.63	5.13
209-4-4-2-8	1327	102.7	37.0	1.15	3.76	4.65
209-4-4-2-6	1314	101.7	37.3	1.14	3.83	4.58
44-10	1292	- -	35.5	1.13	3.51	4.68
231-13-4-11-8	1279	99.0	36.6	1.12	3.91	4.59
209-4-4-2-1	1275	98.7	37.4	1.16	3.81	4.43
231-13-2-2-1	1239	95.9	36.1	1.17	3.84	4.37
209-4-4-2-2	1231	95.3	37.0	1.16	3.85	4.48
231-13-4-11-1	1216	94.1	36.9	1.12	3.80	4.52
205-3-3-3-9	1194	92.4	35.0	1.20	4.15	4.60
206-10-2-2-1	1194	92.4	35.8	1.16	4.06	4.84
231-13-4-11-3	1193	92.3	36.1	1.14	3.85	4.53
231-17-1-1-1	1180	91.3	36.2	1.12	3.83	4.24
231-17-1-1-5	1139	88.2	36.1	1.14	3.70	4.44
L S D P. 01	156	- -	- -	0.03	0.18	0.19

*Lint per cent is a weighted average from first and second pickings.

Samples of most of the strains were sent to the Agricultural Marketing Service Spinning laboratory at College Station, Texas, and spun into 22s and 50s yarns.

The results of these tests are shown in Table 3.

TABLE 3

Spinning Values for the F_7 Strains and 44 are shown below:

Strain No.	Staple Length	Yarn Strength 22s	Yarn Strength 50s	Nep Count	Yarn Appearance	% Waste
227-12-1-4-4	1 3/32	140	49	6	115	8.30
Deltapine S L	1 1/32	113	39	8	115	7.31
228-1-3-2-1	1 3/32	132	45	9	110	8.50
209-4-4-2-5	1 3/32	132	47	7	115	8.19
227-12-1-4-11	1 1/16	138	49	7	115	9.09
221-7-3-5-5	1 1/8	132	47	6	115	8.17
209-4-4-2-8	1 3/32	132	47	9	105	8.95
209-4-4-2-6	1 3/32	135	48	4	105	8.37
44-10	1 3/32	119	42	6	110	8.80
231-13-4-11-8	1 3/32	136	49	6	110	8.95
209-4-4-2-1	1 1/8	134	46	8	105	8.65
231-13-2-2-1	1 3/32	133	47	11	110	8.14
209-4-4-2-2	1 3/32	141	50	6	115	8.56
231-13-4-11-1	1 3/32	137	49	8	110	8.19
205-3-3-3-9	1 5/32	136	49	6	110	7.49
206-10-2-2-1	1 1/8	136	50	7	115	7.30
231-13-4-11-3	1 1/8	140	49	7	115	9.39
231-17-1-1-1	1 3/32	141	51	11	105	7.65
231-17-1-1-5	1 1/8	132	46	10	110	8.35

Eighteen of the strains spun in 1960 were also spun in 1959. A comparison of the average results obtained for the two years is interesting but hard to explain. Strength of 22s yarns was 10 pounds per skein greater in 1959 than in 1960. There was a difference of 3 pounds in the strength of

50s in favor of the 1959 crop. There were nearly three times as many neps per 100 square inches of card web in 1960. Yarn appearance was one-half grade better in 1959. There is no logical explanation for these differences, all of which were in favor of the 1959 crop.

Three hundred sixty-one plant selections from ten F_2 populations were made at the Cotton Research Center in 1960. Ninety of these survived laboratory testing. Low lint percentage and inadequate staple length were responsible for the elimination of a majority of the selected plants. Fiber strength and fineness were also factors involved.

2. BREEDING COTTON FOR DISEASE AND INSECT RESISTANCE AND FOR PLANT TYPES SUITABLE FOR MECHANICAL HARVESTING.

Project Number: 278. Funds: Hatch and State. Personnel: W. D. Fisher, D. C. Allison, E. H. Pressley, H. Muramoto, C. D. Manderscheid, Jean Dykeman, Lester M. Blank, ARS.

Twenty-two new wilt tolerant strains were yield tested for the first time in 1960. At Marana eleven of these strains yielded as well or better than 44 WR, although none exceeded 44 WR by a significant amount. At the Cotton Research Center, where wilt was not a factor, only four of these strains yielded as well as A 44, the standard used for comparison at that location. Tests involving the component lines of the 44 WR variety indicate no improvement in yield, wilt tolerance, or fiber quality, could be made by changing the composition of the variety. California 4-42 again proved to be a good yielding variety under wilt conditions.

Five hundred thirty-four plant selections were made from wilt lines ranging from F_2 to F_5 generation with 150 of these remaining after laboratory testing. One hundred fifty plant selections were made from the variety Wescot. This variety has been outstanding in yield trials but is somewhat deficient in fiber strength and length. Analysis of these selections indicate the possibility of appreciable gains in fiber strength and to a lesser degree in fiber length.

Eleven new crosses were made and sent to Iguala for winter increase. In addition a mass crossing system started in 1959 and involving eight wilt tolerant strains was continued in 1960.

The glandless breeding program under the direction of Dr. Muramoto was continued in 1960. Efforts are being made to incorporate the glandless character into several breeding lines in addition to the varieties A 44 and 44 WR. A backcross system is being used and the source of the glandless character is A44-15-9-5-9 developed by Dr. Scott Mc Michael at the Shafter Experiment Station in California.

3. BREEDING LONG STAPLE COTTON (GOSSYPIUM BARBADENSE) FOR LENGTH, FINENESS AND STRENGTH OF FIBER AND IMPROVED TYPE OF PLANT WITH HIGH PRODUCTION.

Project Number: 294. Funds: Hatch and State. Personnel: W. E. Bryan, H. Muramoto.

The extra long staple cotton breeding program comprises three phases:

1. Basic genetic study
2. Application of genetic principles in breeding methodology
3. The testing of advanced strains

Emphasis has been directed toward the application of genetic principles in breeding methodology with the following work carried on last year.

Selfing and crossing were made in the Breeding Block as usual to produce further desirable combinations of lint and yield character for future plant selections.

146 individual plant progenies of 2-2-2-3 were grown in 50 and 100 ft. progeny rows for selfing and critical evaluation of this advanced strain. This planting was severely damaged by hail storm.

200 individual plant selections of CB-58 were planted in 50 ft. progeny rows. 600 individual plants were selected from the 50 ft. progeny rows and a bulk planting of CB-58, to make the next mixture increase of advanced strain CB-58. Seed from 200 plants were selected, before mixing, for the 1961 planting of 50 ft. progeny rows in order to make a critical evaluation of the mixture. The continued fine performance, in yield and lint quality, of advanced strain CB-58 which was developed under a different breeding method is encouraging. The performance of CB-58 will be critically evaluated in the next few years to determine the efficacy of the method used in its development. A replicated test showed advanced strains CB-58 and 2-2-2-3 to be comparable to Pima S-2, the new commercial variety, in yield and quality of lint.

Six replications of Pima S-1, 2-2-2 and CB-58 were planted in 40" and 80" row spacings in a split plot design to study yield and plant type. The results showed that 40" row spacing gave significantly higher yields than 80" row spacing per unit area. Very little differences in plant type were observed. Data on mechanical harvesting efficiencies and fiber quality is now being processed.

A row spacing test using Pima S-1 in 36", 40", 60", and 72" row spacing was planted in an incomplete block design with 3 replications to observe yielding potential and plant type. This test was abandoned when over 50% of the plants were killed by Texas Root Rot.

Lint from six advanced strains together with Pima S-1 and Pima S-2 were sent to Clemson, S. C. for a spinning test. Results from the test show all six advanced strains compared favorably with Pima S-1 and Pima S-2 in spinning performances.

4. IMPROVEMENT AND MANAGEMENT OF FORAGE SORGHUM.

Project Number: 492. Funds: Hatch. Personnel: R. L. Voigt. (Cooperating with University Experimental Farms.)

The result of the 1960 Forage Sorghum Research Program can be summarized

as follows:

1. A number of hybrids and some varieties of forage sorghums were tested at four locations in 1960 for forage yield (at 70% moisture), height, lodging, maturity, and chemical composition. Single harvest yields were taken at Marana, Yuma, Mesa, and Snowflake. A double harvest test was planted in March at Mesa.

2. Hybrids have outproduced varieties about 25% over a two-year period. Double harvest increased the total yield about 50 to 60% over single harvest. Varieties responded better to double harvest by giving about 65% more yield from the second harvest over the first compared to a 50% increase for hybrids, however, the total yields for varieties are less.

3. Lodging is a serious problem and may be partially controlled by using earlier maturing or sorghums shorter in height. Hybrids generally produce greater yields and should be used where lodging is not a problem, such as in areas of shorter growing seasons. The forage sorghums have been grouped in general categories of early, midseason, and late maturity for purposes of making recommendations to farmers in different areas of the state.

4. Regular Hegari, Tracy, and Lindsey 101 F forage sorghums were cut at seven stages of development in a "stage of harvest" study at Marana. Regular Hegari and Lindsey 101 F were used in the same type of study at Mesa. The chemical samples have not been analyzed yet so the results are not complete.

5. A date of planting test using Regular Hegari and Lindsey 101 F planted every three weeks was run at Mesa. The results are not fully tabulated yet.

6. Eleven sudangrass varieties and hybrids were tested at Mesa by being cut in early bloom for hay or earlier with less growth to simulate grazing. Nearly three times as much dry matter per acre was obtained by cutting for hay versus cutting or grazing at an earlier stage of growth. California #23 (or Sudan #23) produced very well when utilized as either hay or forage and has the added attribute of good recovery after cutting or grazing. Tift had a medium rank in yield of hay or forage while Sweet 337 ranked low for both uses. All other entries yielded better for one use but poorer for the other. Gahi Millet performed best, relative to the other entries, when cut as a forage. Sudo-sudan gave its best performance when cut for hay.

A simulated grazing or forage trial was conducted at Tucson for performance and recommendation purposes in that area.

7. The moisture samples from all of the forage sorghum and sudangrass tests were saved to be ground and analyzed for chemical content which have not yet been completed. The chemical analyses will be for digestible laboratory nutrients (DLN) and protein for measures of feeding value.

8. Crosses were made in the field and some F_1's grown and selfed.

5. IMPROVEMENT AND MANAGEMENT OF GRAIN SORGHUM.

Project Number: 493. Funds: Hatch. Personnel: Lee S. Stith, T. C. Tucker and Paul D. Keener.

The results of the 1960 Sorghum Research Program can be summarized as follows:

AGRONOMIC STUDIES

1. A study involving the "Interrelationship of Sorghum Varieties and Nutrients" was summarized in 1960 with Dr. T. C. Tucker, Agricultural Chemistry and Soil cooperating, the study was begun in 1958. Three hybrids and a standard variety were grown in each of four locations in Arizona in the years of 1958 and 1959. The hybrids included ranged from early to late in maturity (RS 501, RS 610, and Texas 660) and were grown in environments from hot and dry (Yuma) to the more ideal in the higher altitudes of Eastern Arizona, near Willcox. Superimposed on the variety test were nine fertilizer treatments included in a range of 0 -- 240 pounds of nitrogen per acre alone and in combination with phosphate.

   The objectives of the experiment were to measure yield responses of the hybrids and standard varieties, and to study components of yields. The conclusions were:

   a. Hybrids as a group outyield standard (open pollinated) varieties.

   b. No interaction was observed between various nutrient levels and varieties.

   c. Reference to components of yield:

      (1) Fertilizer at any given level did not change the number of heads per unit area.
      (2) There were significant differences in weight per head.
      (3) No significant differences between the volume of the grains as measured.
      (4) No real differences in the weight of 500 grains.
      (5) Significant differences in the number of grains per head.

   The conclusions of this work are two-fold: (1) The plant breeder can well afford to select toward heads with larger number of floret potential, and (2) The agronomist can apply fertilizer and water early enough too, in the life of a plant to affect primordial differentiation.

2. Not previously reported by this department was a cooperative study with Mr. Leonard Erie, U.S.D.A., relative to consumptive use of water. To control western corn stalk borers, an irrigation shortly after emergence of the plants was applied, and this treatment made the highest yield. As a result of information of these two studies, the Agricultural Engineering and Plant Breeding Departments are starting a study to determine when to irrigate and what level of moisture should be maintained to obtain highest yields of sorghum.

3. Cooperating with Agricultural Chemistry and Soils, a long-time rotation study was initiated at the Cotton Research Center. Varieties of sorghum and systems of management are to be used in comparison with alfalfa and management to maintain productivity levels of cotton. Superimposed on the sorghum was a fertilizer trial using N and P. Direct responses to N were obtained. Phosphate also made a real difference in yield this year.

4. Double harvest at the Mesa Farm was continued this year to further check for the effect on yield of row width, harvest methods, and time of harvest. Stubble left at combine height gave the best regrowth. One harvest of a single planting made in March looks very good, even though bird damage prevented the results from being accurate.

   At Yuma, double harvest using NK 300 was tried. This hybrid was used because it responds photoperiodically to day length. Yields of 7,000 pounds of grain per acre were obtained at the July harvest and 20 tons of silage from the stubble in November. This suggests a new management technique.

5. Yield tests were made at Yuma, Mesa, and Marana. Hybrids that are adapted to areas outyield the open pollinated varieties by as much as 25%. Narrow width rows (15 inches apart on a bed) were used in 1960 yield tests to increase plant population to 100,000 plants per acre. With high plant populations, hybrid yields are more competitive with the standard varieties that sucker freely.

PATHOLOGICAL

1. With the Plant Pathology Department, the occurrence of Virus (?) on sorghums was observed at Mesa. Seventy two entries were compared with previous years' performance. The incidence of disease was low and unsatisfactory results were obtained.

BREEDING WORK

1. In the crossing nursery at the Campbell Avenue Farm, a dwarf hegari cross (possibly a 4 dwarf) was used as the male parent on steriles to study the effect on F_1. A series of quadruple dwarf stocks (milo type) were used also.

2. F_1 plants from 4 dwarf origin were selfed for advancement to F_2 to obtain F_2 segregates.

3. F_1 material from previous year was evaluated.

4. A preliminary pollination study was made at Marana to relate humidity, temperature, and wind to seed set at various hours of the day.

Department of
PLANT PATHOLOGY

1. CONTROL OF PHYMATOTRICHUM (COTTON OR TEXAS) ROOT ROT IN IRRIGATED LANDS.

Project Number: 42. Funds: Hatch. Personnel: R. B. Streets, R. M. Allen.

Cotton and other summer annual crops: Squash (Banana) and Sesame have been added to the list of susceptible annual crops (cotton, castor beans, soybeans, cowpeas and watermelon) for which the most practical control is a winter green manure crop of Papago peas.

Chemical control: Chemicals have been effective in control of root rot in woody plants and trees not more than moderately susceptible. So far, no chemical has shown promising eradicant effect. Plots uniformly and severely infested are maintained for field tests.

Alfalfa: Three half-acre borders uniformly and severely infested with root rot have been used by Dr. Keener and Dr. Schonhorst for testing alfalfa varieties and progenies for resistance to root rot. (Reported under Hatch 227).

Stone fruit trees: Root rot has not yet been controlled in stone fruit orchards. A fourth year with applications of surface mulches plus organic matter in post holes has given very encouraging results in a thrifty 6-year-old planting of peaches, apricots and plums.

A winter green manure crop of Papago peas is recommended before planting cotton, castor beans, soybean, cowpeas, watermelons, squash, or sesame on root-rot infested land. The use of organic matter in holes, and mulches of manure, and ammonium sulphate and sulphur is recommended as the best available treatment for root rot in stone fruit plantings.

2. CONTROL OF ROOT DISEASES AND VIRUS DISEASES OF CITRUS.

Project Number: 222. Funds: Hatch. Personnel: R. M. Allen, R. B. Streets, H. H. McDonald, and R. D. Rodney, University of Arizona; and J. B. Carpenter, U.S.D.A.

A field test aimed at reproducing dry root rot by incorporation of organic materials into the root zones of young Valencia trees was completed. None of the materials (fresh manures, hay, straw, peat moss - all applied in excess directly onto buttress roots) induced dry root rot within 14 months of treatment nor were other ill effects noted. A collection of case histories has been made of instances where dry root rot has occurred: the disease is most severe in coarser sandy soils when excesses of ammonia developed either from organic or chemical sources. Irregular irrigation practices have increased the severity of effect and incidence, especially in young, non-established trees. Tests involving effects of ammonia on canned seedling and budded trees have been started. Initial symptoms including root cortex sloughing have been recorded. To date, 216 tree entries have been made in the virus indexing program. These include nucellar and selected old-line varieties imported from

California, old lines locally established, and diseased specimens. Fifty of the entries are budded into a complete series of indicators; the balance are budded into one or more of the short-term indicators in green- or screen-house. No important differences have been found yet in the long-term study of Stubborn Disease.

3. DISEASES OF ROOTS AND ROOT CROWNS OF ALFALFAS IN ARIZONA INDUCED BY SOIL-INHABITING PATHOGENS.

Project Number: 227. Funds: Hatch and State. Personnel: Paul D. Keener, Melvin Schonhorst.

Approximately 500 accessions (chiefly selections from the non-hardy alfalfa variety, African) were examined for retention of stand, response to leafspots and mildew and the presence or absence of root rot and crown rot. In the latter case, some observations were made on presence or absence of rot in the crown buds.

About 20 of these accessions appear to have retained good stands after 2 1/2 years in soils of the Salt River Valley, while 31 have survived in fair to good condition. All of these accessions (total 51) apparently have lost much of their susceptibility to Downy Mildew (Peronospora trifoliorum) and there are indications that symptoms of viruses are becoming less marked. Many of the remaining selections (51) when classified for general growth and appearance on a "good to very good" (0-1) and "fair to good" (1-2) basis, have developed some root discoloration. The exact nature of this is not known. In many cases deep-yellow-colored wood, usually associated with bacterial wilt (Corynebacterium insidiosum) or Dwarf virus (Morsus suffodiens) infections, is absent so that the noted root discoloration (usually brown) is apparently not associated with either of these pathogens. A peculiar root pitting condition has been recorded in some of the accessions not surviving as well as the 51 indicated above.

The accessions surviving best up to Jan. 1, 1961, are coded as follows:

Survival ratings of the best alfalfa selections in a four replicated, randomized area in the Salt River Valley

Class (0-1) Good to Very Good	Class (1-2) Fair to Good	
AP-15	A4-35	Moapa (Cert.)
E-34	E-31	Moapa (Found.)
E-38	E-34	N-1059
E-40	E-35	P-14
I-4-3	E-39	P-15
I-5-1	E-40	Y-5-26
I-5-4	E-66	Y-5-96
I-6-5	H-37-2	
I-7-3	I-2-5	
Lahontan	I-3-2	
M-5-9	I-4-3	
Moapa (Cert.)	I-4-5	
Moapa (Found.)	I-5-4	
N-1041	I-6-3	
N-1059	I-6-4	

Alfalfa diseases (continued)

Class (0-1) Good to Very Good	Class (1-2) Fair to Good
Y-5-9	I-6-5
Y-5-10	I-11-2
Y-5-48	I-17-1
Y-5-56	I-20-2
Y-5-83	I-53
20	Iran (Ariz. Acc. No. 264)
	Lahontan
	M-5-4
	M-5-71
	31

Note: The appearance of a specific accession in both categories means that all of the replicates could not be classed under a single class.

Of interest in this connection were the classifications of the following accessions: Lahontan, placing only 1 area in each class. Usually this variety is one of the most enduring types as far as longevity of stands is concerned. Here though (not shown in the results presented) the other 2 of 4 replicants of this variety were in the poor to very poor classification. The strong resistance of Moapa (Foundation) which actually placed all 4 replicates in the two classes, equally divided. Moapa (Certified) also was a strong survivor, and appears in both classifications. Other accessions meeting the criteria of both classifications (0-1 and 1-2) were: E-34, E-40, I-4-3, I-5-4, I-6-5 and N-1059.

Among these accessions is one (I-5-4) which develops a peculiar broken yellowish-white ringspot on leaflets at certain times of the year. An isolation of a broken ringspot virus from this accession was made and the symptoms consisted of broken, necrotic rings on Nicotiana sylvestris. At the end of the second year, this selection although a good producer of top growth with moderate recovery after cutting, developed a tendency for susceptibility to common leafspot caused by (Pseudopeziza medicaginis). The numerical designation of this selection is now N-1074 and is a part of Moapa development.

Further studies relating to leafspot occurrence and also susceptibility to Downy Mildew caused by Peronospora trifoliorum, are continuing.

4. VERTICILLIUM WILT OF COTTON.

Project Number 256. Funds: Hatch. Personnel: Ross M. Allen and H. H. McDonald.

A field study compared wilt incidence as influenced by soil temperature in East-West cotton beds with those oriented in the North-South direction. Daily mean temperatures showed E-W beds warmer (0.5 to 8.5 deg. F.) than N-S beds at bed center, six inch depth. Daily temperature fluctuations averaged eight degrees in N-S beds and five degrees in E-W beds. For all of the period of record (April 2-

July 20) soil temperature in all beds was well within the optimum range for Verticillium. Stand counts before thinning and height of plants on May 3 were best in E-W rows. Four counts of visibly diseased plants at monthly intervals consistently showed more disease in E-W rows. Foliar symptom severity was approximately equal in the two treamments during May. In June and August foliar symptoms were indistinct in the E-W block but clear in the N-S block. This observation is in sharp contrast to that of last year when foliar symptoms were non-existent as early as mid-July. Examination of vascular tissues of twenty-five randomly selected plants in each treatment in August showed practically every plant diseased although few showed foliar symptoms or defoliation effects. In December, following harvest, detailed examination of 15,874 stalks revealed only 10 non-infected plants. Surveys during June, 1960, of 24 additional cotton fields located near canals or drainage systems in the central and southern parts of the Yuma Valley have yielded no new infested localities.

5. CAUSE AND CONTROL OF CROWN BLIGHT OF CANTALOUPS.

Project Number: 317. Funds: State. Personnel: Merritt R. Nelson, Ross M. Allen, Donald M. Tuttle, and Herbert H. McDonald.

Cantaloup plantings made at bi-weekly intervals (Feb. 1 to March 30) showed higher yields of marketable fruit in dates 1-4 than the 5th date. No difference in spread of mosaic was noted between unsprayed half of plots and half that was sprayed weekly with .5% dimethoate. No difference in crown blight rating was noted between any of the treatments.

Cantaloups planted after a papago pea green manure crop, 20 tons steer manure per acre and 700 pounds calcium cyanamide showed no differences among themselves or with continuous cantaloups.

Results of a second year test of the effectiveness of a barrier trap crop in slowing down aphid spread of mosaic viruses was negative.

Controlled field and greenhouse tests of the effect of isolated and identified mosaic viruses on cantaloups, failed to show any correlation between mosaic infection and crown blight symptoms. Yield and quality of cantaloups, however, were greatly reduced by early infections with either melon mosaic or cucumber mosaic viruses. Late infections, in respect to plant size and fruit maturity, were less injurious.

Samples collected from 134 cantaloup plants showing mosaic symptoms were used to make greenhouse isolations and identification. Analysis of collections revealed that 89.6% were melon mosaic, 3.9% cucumber mosaic and in 6.5% both were present.

6. NATURE AND CONTROL OF SOIL-BORNE DISEASES OF LETTUCE.

Project Number: 318. Funds: State. Personnel: R. B. Marlatt, R. T. McKittrick.

Big Vein

Four fungicides were applied to infested soil in an attempt to control big vein

in Great Lakes 66 lettuce: calcium cyanamide, 1,000 pounds, chloropicrin 35 and 70 gallons, dichloropropenes-dichloropropanes (D-D) 20 and 40 gallons, and PCNB (75 percent) 200 pounds per acre. Part of each chloropicrin and D-D plot was tarped with plastic immediately after injection. Treatments were randomized and replicated 4 times. Tarped chloropicrin (70 gallons) and PCNB (200 lbs.) provided significant control of big vein; however, PCNB stunted the lettuce and the high rate of chloropicrin is too expensive for commercial lettuce production.

Testing irrigation water for the fungus that probably causes big vein failed to reveal its presence. Water was collected from the University Farm pipeline and from plot ditches and used for irrigating plants in the greenhouse.

Plant size was estimated by measuring plant diameters, top weights and counting leaves on 80 diseased and 80 normal plants shortly before harvest. Comparisons showed that all 3 size measurements were decreased significantly by big-vein infection.

Maturity of lettuce, as estimated by head size and firmness, was observed in 868 plants, half of them normal and half showing severe big-vein symptoms. By the time the majority of big-vein and normal heads had matured, 94% of normal and only 68% of big-vein affected plants had formed mature heads. This difference was statistically signficant (5% level).

Seed yields were obtained from 430 plants, half of which had severe big vein before heading and half appeared normal. Seed from each plant was harvested separately, cleaned and weighed to the nearest hundredth gram. Group comparison of seed weights revealed that there was no significant difference in yields from big-vein vs. normal plants.

7. ANTIBIOTICS IN RELATION TO PLANT DISEASE CONTROL.

Project Number: 359. Funds: State. Personnel: Alice Boyle.

Preliminary experiments with vancomycin in crown gall control started last year were continued and expanded. Rose root-stock cuttings and tomato plants were used in the greenhouse studies with the following results: (a) Rose root-stock cuttings soaked in vancomycin solution and planted in sterile soil developed roots and foliage containing measurable amounts of the antibiotic. Tomato plants treated by immersing roots in vancomycin showed effective concentrations in all plant parts with the highest concentration in the crown. (b) Vancomycin used as a soil drench prevented infection in inoculated tomato plants and rose root-stock cuttings. Vancomycin is not rapidly inactivated in soil. (c) Vancomycin treated tomato plants and rose root-stock cuttings failed to develop crown gall when planted in soil heavily inoculated with Agrobacterium tumefaciens. (d) The antibiotic is not phytotoxic at high concentrations used.

8. DIAGNOSES OF PLANT DISEASES.

Project Number: 360. Funds: State. Personnel: Alice Boyle, R. B. Streets.

Over 600 plant disease problems have been diagnosed and reported upon during the year. Specimens were sent or brought to the laboratory by county agents, extension personnel, nurserymen, farmers and home owners.

The following is the only new disease to come to our attention and be studied this year: A root and crown rot of dichondra caused by Pythium sp.

9. CHEMICAL CONTROL OF NEMATODES AFFECTING VEGETABLES.

Project Number: 406. Funds: Hatch and State Research. Personnel: Merritt R. Nelson.

Several chemicals were tested for their effectiveness in controlling root knot nematode of cantaloup with the following results (plots were 20 x 390 feet - 6 treatments, 4 replicates).

Chemical	Rate	Root Knot Index*	
1,2 -Dibromo-3-chloropropane (DBCP)	3 GPA	10.75	*0-No knots
Dichloropropane and Dichloropropene (D-D)	25 GPA	11.50	10-Few
1,2 -Dibromo-3-chloropropane (DBCP)	8 GPA	12.25	20-Moderate
Dichloropropane & Related C_3 hydrocarbons (Telone)	20 GPA	23.50	30-Severe
Ethylene dibromide (EDB)	8 GPA	29.25	40-Death
Control	--	33.75	

An experiment is in progress to find the most suitable rate of ethylene dibromide (previously found best in trials) for the control of root knot nematode of tomato. Three rates have been applied; another fumigant, trizone, has been tried for the first time. Plants in trizone plots look better than those in any of the EDB plots; it also is a good weedicide and has fungicidal properties. (Trizone - Methyl Bromide 61% Chloropocrin 31% Propargyl Bromide 8%.)

10. WOOD-NECROSIS GUMMOSIS OF CITRUS.

Project Number: 407. Funds: Hatch. Personnel: Ross M. Allen and H. H. McDonald.

Gumming attributed to wood necrosis gummosis occurs most in late spring and least in mid-summer. Gummosis expression nearly doubled in two years (1958-60) and now occurs in 83 percent of 2166 mature grapefruit trees on the Yuma Station. Trees having both gummosis symptoms and scaly bark (psorosis) gum more frequently than those having only one of the diseases evident. Eighty-nine percent of scaly bark trees show gummosis symptoms. A recent count of trees showing mature leaf symptoms

of psorosis revealed twice as many test-block trees have psorosis than known previously. These facts suggest a relationship between psorosis and gummosis.

Inoculations of a still unidentified fungus, probably a basidiomycete, caused typical wood decay in 3-year-old grapefruit tree trunks. Decay, though not extensive, occurred nearly equidistant above and below inoculation sites after 18 months. Re-isolation of the fungus was inconsistent. Inoculations of twigs and branches of mature trees with five different organisms by several methods also failed to cause extensive invasion seventeen months after inoculation. Greatest invasion occurred where Diplodia sp. was used as inoculum. The unidentified basidiomycete was recovered more frequently than the others.

11. CONTROL OF MILDEWS OF MUSKMELON AND LETTUCE.

Project Number: 408. Funds: Hatch and State. Personnel: R. B. Marlatt, R. T. McKittrick.

Lettuce Downy Mildew

Oversummering of the mildew fungus may occur in Arizona since the disease invariably appears in winter-grown lettuce if weather is favorable for it. Wild lettuce (prickly lettuce) and a Great Lakes variety were infected in the greenhouse and then transplanted to the field into cotton, sorghum, and fallow plots for the summer. Only 29 of 210 head lettuce plants survived the summer and 208 of 230 prickly lettuce plants survived. These survivors were transplanted to the greenhouse and subjected to conditions favorable for mildew sporulation. After 3 weeks they were examined for mildew; 1 head lettuce and 163 prickly plants were alive when examined. No mildew was found on living or dead plants.

The potential lettuce reservoirs of the disease lasted through the summer in fallow plots as well as in the shade of cotton or sorghum. It remains to be proved whether or not they are the annual source of mildew.

Inoculations with root-stem tissues were made in the greenhouse. Tap roots and attached stems were obtained from severely mildewed heads, leaves removed, surfaces disinfected and the macerated root and/or stem tissues poured over 10 young healthy plants. None of the inoculated plants became infected even though conditions were shown to be favorable for downy mildew by severe infections in spore-inoculated controls.

Effects of temperature on stem invasion by the downy-mildew fungus were studied by storing 48 root-stem pieces from severely mildewed plants at 38, 43, 48 and 60°F. for at least one month. No mildew fungus was found after storage. The effect of rising storage temperatures on 24 similar root-stem pieces were noted by moving them at weekly intervals from the lower to the higher temperatures. Again no signs of the fungus were found by microscopic examination. Five mildew-inoculated plants were grown under infra-red lamps in the greenhouse until they approached head maturity and four controls were inoculated and grown at normal greenhouse temperatures. None of them showed stem invasion by the mildew fungus.

Soil transmission of mildew was attempted by partially burying root-stem pieces from severely mildewed heads in sterile soil which was then planted to lettuce. Plants in 24 of such pots failed to develop mildew.

A search for oospores was made to determine if this dormant stage of the mildew fungus occurs in Arizona. Fifty severely infected heads and attached roots were stored at 34, 43, 48, 60 and 80°F. Mildew lesions were removed from the heads at weekly intervals, cleared, stained and examined for oospores. No oospores were found over a 2-month period. In a similar test, 30 large infected leaves were obtained from a severely diseased field, stored at the 5 temperatures and examined for oospores without finding any.

Inoculation with dried leaves which were severely mildewed was tried in the greenhouse. Young plants were sprinkled with a coarse powder consisting of mildewed leaf lesions which were air-dried at room temperature for over a month. None of the 24 potted plants thus inoculated developed mildew.

12. INTERRELATIONSHIPS OF MOSAICS AND SIMILAR VIRUSES AFFECTING VEGETABLES AND OTHER PLANTS IN ARIZONA.

Project Number: 478. Funds: Hatch and State. Personnel: Paul D. Keener.

Mosaics and similar viruses: Cucumber and squash mosaics as well as yellow-, green- and necrotic-ring spot viruses were the most prevalent pathogens isolated from crop and other plants in Arizona. Ringspots were also found in tomatoes and watermelons shipped through the Port of Nogales from the growing areas on the West Coast of Mexico. In the case of the yellow and green ringspot viruses and in instances where squash mosaic was used in inoculations onto various test plants in the greenhouse, intense distortion and necrotic veins and sectors appeared. One isolation from honeydew melons from the Salome area caused death of test plants in 10 days. This virus also caused local, necrotic, concentric rings in Nicotiana glutinosa much as would be anticipated in the case of ordinary strains of tobacco mosaic virus (Marmor tabaci). The honeydew fruits exhibited symptoms of "pimples."

A necrotic ringspot virus was isolated from Sonchus asper (Sow-thistle) plants growing in the vicinity of both alfalfa and potato fields in the Queen Creek area. In addition, a virus resembling the so-called Rattle pathogen was also isolated from the same plant. These two viruses in combination caused necrotic sectors and collapse of leaves of Arizona Sunrise cantaloups inoculated under controlled conditions in the greenhouse. Also, the reaction of this combination on Cowpea (Vigna sinensis) was quite similar to that secured on the same host when inoculated with a virus recovered some time previously from Hubam Clover (volunteer plants) from Oak Creek Canyon.

The bronze-vein syndrome in melons, usually followed by collapse of crown-leaves and sometimes followed by gray-green sectoring, then necrosis, was reprcduced by isolations from honeydew melons, watermelons and tomatoes. Watermelon isolations giving these reactions on cantaloups were usually taken from fruits showing "rind-rot" or "yellow-streak." This result was in contrast to that secured by workers in Hawaii.

Viruses isolated from ornamental plants during the year were: a strain of Cucumber mosaic (Marmor cucumeris) from Azalea (unident. variety) shipped to Tucson from a California nursery. These plants were intended for the Easter season trade and in addition to stunting had flowers with typical "color break." Of interest here is the fact that cucumber mosaic may exist in a woody plant, a situation now

accepted as valid but thus far not proven to be of general occurrence.

A strain of tobacco ringspot virus (Annulus tabaci) was isolated from leaves of a specimen of Gardenia from a Tucson residence. No reports of this virus in this host have apparently ever been made. Prominent necrotic rings in fairly large spots were evident on leaves of this plant.

A virus unusual in Arizona was noted on Celery (Apium graveolens var. Giant Pascal) from a commercial planting in the Salt River Valley. The stalks of plants exhibited shallow, necrotic, oval to elliptical furrows. The symptoms resembled those caused by the spotted-wilt virus on celery. Isolation showed that the celery calico strain of alfalfa mosaic virus (Marmor medicaginis) was the pathogen. Since virus studies began at this Station, Yellow Spot, California Aster-Yellows, Cucumber mosaic and Celery Calico viruses have been shown to exist in commercial plantings of celery in Arizona.

Cucumber mosaic viruses were also recovered for the second season from certain varieties of Sorghums grown at the Mesa Station.

Curly-top in Tomato: Two areas with randomized plots were planted with J. Moran, EarlyPak C 7, Owyhee No. 1 and Owyhee No. 2 tomatoes. In addition some lines of tomatoes supposedly resistant to curly-top virus strains and developed by the personnel of the Department of Agriculture, ARS at Logan, Utah were included. In cooperation with the Department of Agricultural Chemistry and Soils, certain soil, side-dressing, and spraying treatments consisting of chelates and minor elements were utilized in the plots. Readings were made for the presence or absence of internal symptoms of curly-top virus attack. Positive readings were recorded in those cases in which stem sections showed necrotic phloem. Other data such as fruit yield, etc., were collected by the cooperating Department.

In one experiment incomplete results show that there are no differences among the chemicals in their action in inhibiting the development of curly-top virus symptoms in the phloem of tomato plants.

Effect of chemicals - inhibition of symptoms (phloem necrosis) of curly-top Virus.

Chemical Code No.	No. hills in plot	No. of plants sampled	No. of stem sections examined	No. of stem sections showing phloem necrosis*
1	163	306	1,229	1,207
2	149	278	1,102	1,080
3	161	306	1,214	1,175
Totals	473	890	3,545	3,462
Checks (4)	55	96	382	365
Grand Totals	528	986	3,927	3,827

*Examination made with a compound microscope.

Results analyzed in another manner show that the method of application of chemicals had no inhibitory effect on the occurrence of necrosis in the phloem of the experimental plants.

Occurrence of phloem necrosis in tomato plants vs. method of application of certain chemicals

Chemicals applied as	No. of Hills in plot	No. of plants sampled	No. of stem sections examined	No. of stem sections showing phloem necrosis*
Banded with N (a)	152	286	1,174	1,117
Applied with seed (b)	163	307	1,229	1,194
Sprayed on plants (c)	158	297	1,172	1,151
Totals	473	890	3,545	3,462
Checks (4)	55	96	382	365
Grand Totals	528	986	3,927	3,827

*Based on examination with a compound microscope.

In another experiment it was found that similar chemicals including an inorganic mix applied to the soils had no inhibitory effects on the occurrence of phloem necrosis in plants of J. Moran, Owyhee No. 1 and 2 and certain of the Utah selections. There was some tendency to lessen the symptoms of tobacco virus (Marmor tabaci) where the inorganic trace mix was used.

Effects of certain chemicals applied to soils on occurrence of phloem necrosis in various tomato varieties

Chemical code Nos.	No. of hills in plots	No. of plants sampled	No. of stem sections examined	No. of stem sections showing phloem necrosis
1	45	91	356	300
2	39	75	296	237
3	44	90	373	318
4	50	102	468	392
Totals	178	358	1,493	1,247

13. ANATOMICAL AND SEROLOGICAL STUDIES ON STUBBORN DISEASE OF CITRUS.

Funds: State Research. Personnel: R. B. Streets and Leonard W. Storm.

An anatomical study of healthy and diseased leaves of several citrus varieties was made in an effort to find a means of positively identifying stubborn diseased citrus trees when fruit was not available. It was found that the veins in infected leaves are somewhat coarser than those in normal ones and their terminals tend to be blunted. Healthy citrus leaves were found to contain 3 to 4 times as many calcium oxalate crystals as the diseased leaves. A more extensive program to determine the calcium content of leaves both of healthy and diseased trees infected with stubborn and other citrus viruses is now in progress.

Juice from diseased fruits of several citrus varieties was prepared and injected into rabbits. The antiserum obtained, normal serum, and juice from healthy and diseased fruits were tested in all possible combinations by a micro-precipitin test. Results indicate that closely related proteins are involved in the disease in Marsh and Red Blush grapefruit. An unrelated protein is involved in the infection of Washington Navel trees. Studies are now underway to determine if these proteins are viruses.

14. COTTON DISEASES IN ARIZONA.

Funds: State. Personnel: Ross M. Allen, H. H. McDonald, U. of A.; L. M. Blank, R. N. Garber, USDA; and C. R. Maier, New Mexico State University.

Seven fungicidal dusts were applied to seed furrows as cotton was planted. Counts of seedling stand and disease incidence were made on two dates. On April 4, no differences were found for disease; however, stand counts showed a highly significant difference: The Captan treatment had less stand than any of the others. On April 18, significant differences were found for disease control: All treatments were better than either the checks or one treatment in which a mechanical failure resulted in an inadequate application rate. Cultures of diseased cotton seedlings showed Rhizoctonia sp. the principal pathogen.

As part of a regional test in cooperation with the National Cotton Disease Council twelve specially treated lots of seed (including checks) were planted in a replicated test to determine effectiveness of the selected seed-treatment fungicides in controlling damping-off. Statistical analyses were made for both stand counts and disease incidence on two recording dates. No differences were found. Post-emergence seedling disease ranged from 1-4% only. Mean percentage emergence ranged from 71-81% of the planted seeds.

15. CHEMICAL CONTROL OF MILDEWS OF LETTUCE AND CANTALOUPS.

Funds: 2 RC - Cal Spray. Personnel: Merritt R. Nelson.

Lettuce Downy Mildew control tests in 1959-60 showed that the most effective fungicides were phaltan, zinc coposil, copper sulfate and dithiocarbamate (zineb).

Tests are in progress now to evaluate these materials: Phaltan 2 pounds per acre; zinc coposil 4 pounds per acre; copper sulfate 4 pounds per acre, and naban 1 pound per acre + manganese sulfate 1 pound per acre.

The following fungicides are being tested this spring for their effectiveness in the control of powdery mildew of cantaloups: Phaltan-Spray 2 pounds per acre, 6% dust 30 pounds per acre; Karathane-Spray 1/2 pound per acre WD, 8 ounce 50% EC per acre, 3/4% dust - 30 pounds per acre; Naneb-spray 1 1/2 pounds per acre; zinc coposil phaltan-spray 6 pounds per acre. A similar experiment this past year yielded nothing because mildew incidence was too low.

16. SEEDLING ROT OF THE SAGUARO CACTUS.

Funds: State Research. Personnel: John A. Booth.

In the course of studies on the bacterial necrosis disease of the saguaro cactus a seedling rot was encountered which hampered propagation of plants. A separate investigation of the seedling disease was undertaken.

Two species of Fusarium were isolated which were capable of causing typical disease symptoms. These were subsequently identified as clones of F. oxysporum and F. solani. The latter was infrequently isolated and less pathogenic.

Symptoms of natural infection include cortical collapse with the affected tissues appearing as a dark brown to black, watery mass contained by a more or less intact epidermis. The vascular system is directly involved as the lesion increases in size and brown streaks in the xylem are obvious above and below. Complete involvement of the plant often occurs within 24 hours after the first symptoms are noted.

Preliminary infection studies indicated that the organisms were weakly pathogenic and dependent upon wounds for entrance into the plants. Recent tests however have indicated that the F. oxysporum isolate readily penetrates unwounded seedlings under certain undetermined conditions.

The organisms have been shown to be pathogenic to five other species of cacti commonly associated with saguaro. They were non-pathogenic to economic crop plants representing four other plant families. The cacti were tested by needle inoculation into mature plant parts. The other plants were tested in the seedling stage by adding heavy spore suspensions to mechanically wounded and intact root systems growing in vermiculite. The plants tested were watermelon, pinto bean, flax and tomato. Saguaro seedlings under the same conditions were over 90% infected.

Cardinal temperature and pH values for in vitro growth of the pathogens have been established. Optimum values were shown to be 25-30°C. and pH 3.0-4.5.

Growth was measured in terms of dry weight of cultures after 14 days. Tubes containing 10 ml of Richards' solution adjusted to pH values from 3.0 to 11.0 were inoculated with standard concentrations of spores and placed in the dark at temperatures ranging from 6° to 50°C. Each temperature-pH test was replicated three times. At the end of the growth period the cultures were centrifuged three times with distilled water washing before the second and third centrifugations. The mycelium and spores were then placed on tared pieces of aluminum foil, dried at 60°C. for 24 hours and weighed.

Histological studies involving naturally infected and needle inoculated saguaro seedlings are nearly completed. Interpretation of serial sections has not yet been made.

17. STUDIES CONCERNING PHYTOPHTHORA ROOT-ROT OF SAFFLOWER.

Funds: State. Personnel: Bill B. Berkenkamp.

Cultures

An Isolate of Phytophthora dreschleri was obtained from soil of a previously severely infested plot at the Mesa Experimental station by planting safflower and burying potatoes in pots of soil and isolating from diseased parts. This isolate will be called #3. Culture #10923 was obtained from the American Type Culture Collection.

Pathogenicity

The Mesa isolate #3 is more pathogenic than #10923 on wounded and unwounded tomato fruit and cotton bolls. Number 3 is pathogenic on wounded and unwounded detached Bryophyllum leaves, wounded potato tubers and onion bulbs while #10923 was non-pathogenic. Safflower plants grown in aerated nutrient solutions, were killed in 7 days after 15 days with #10923.

Cultural Characteristics

Number 3 grew well on fresh or canned tomato juice, 3 parts diluted with 7 parts distilled water, potato dextrose agar and oat meal agar. Slow growth was supported on lima bean agar, Richards solution, wort agar. On corn meal agar the growth was spreading and very thin. No growth occurred on Hoagland's nutrient solution with 20 gm dextrose per liter, Difco nutrient broth with 5 gm dextrose per liter. No spores formed on any media except on potato dextrose agar. Chlamydospores were sparsely produced on this medium after 2 months. Mycelial mats of #3 produced sporangia when transferred from media supporting growth to distilled water, a subsequent transfer to another change of distilled water stimulated the release of zoospores. Culture #10923 rarely produced sporangia, and then very sparsely. Zoospores are as effective as mycelium when used as inoculum in aerated nutrient solutions. After swimming for about 30 minutes to 2 hours they round up, lose flagella and germinate. Slides placed under water containing swarming zoospores could be removed with zoospores strongly adhering and stained.

Resistance of Safflower

Nebraska #10 (N-10) a susceptible variety and Gila, a derivative of N-10 with incorporated resistance were used to study the nature of resistance. Seed of Gila and N-10 were tested for a reduction in germination when placed in culture filtrate from Phytophthora dreschleri. Both resistant and susceptible seed germinated well and no inhibition was found. Roots and shoots were separately incorporated into solid media. These were inoculated with Phytophthora. No inhibitions of growth of Phytophthora could be detected. Similar results were obtained when entire plants were ground, with 50% of the fresh weight of plants of water added, filtered and autoclaved; both varieties supported good growth of Phytophthora. The roots of infected plants darken and later decompose. Sections of the margin between diseased and healthy tissue have shown no mycelium or resistant reaction. A dark color and collapse of cells in infected areas is easily demonstrated. These tests tend to show that resistance is not a tolerance to a toxin and does not depend upon a heat stable plasmic substance.

18. FUNGI ATTACKING NEEDLES OF WESTERN YELLOW PINE (PINUS PONDEROSA LAWS) IN ARIZONA AND NEW MEXICO.

Funds: Grant-in-aid Funds from United States Forest Service (Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado and Albuquerque, New Mexico, and State Research. Personnel: Paul D. Keener, U. of A.; Stuart R. Andrews, Chief, Forest Diseases Investigations, Rocky Mt. Forest & Range Exp. Sta.; Paul C. Lightle, Lab. Leader, Forest Insect & Disease Lab.

Approximately 100 collections of diseased needles from Pinus ponderosa and other species, in addition to approximately 500 already examined, were studied for their fungus flora during the past year. The mycoflora connected with these additional samples was qualitatively similar to that in previous collections. Most of the invaded needles came from trees in the National Forests of the State, and in areas likely to be concerned with recreational activities. Among the fungi identified from the collections were:

Among the needles blights

Pestalotia sp.

Dothistroma pini Hulbary

Hendersonia acicola (=Hendersonia pinicola Wehm.)

Diplodia sp.

Phaeoseptoria sp.

Phacidium sp. (a fungus believed to belong in another genus)

Among the needle-cast fungi

Elytroderma deformans (Weir) Darker

Hypodermella concolor (Dearn.) Darker

Hypodermella medusa Dearn.

Hypodermella conjuncta Darker* on Pinus strobiformis

Hypodermella arcuata Darker* on Pinus strobiformis

Hypodermella cerina Darker*

Lophodermium pinastri (Schrad, ex Fr.) Cheval.

*Reported for the first time in this study and in the State.

Additional material of the fungus identified by personnel at the National Fungus Collections, Beltsville, Md., as Lecanosticta acicola (Thümlant) Sydow (=Scirrhia acicola (Dearn.) Siggers)was noted from the Prescott National Forest on P. ponderosa and from other Pinus spp. in the Coronado National Forest.

Multiple infections by these fungi were observed on several occasions on the same trees and even on the same needles, the most common associations being: Elytroderma deformans and Hypodermella medusa and Elytroderma and the Phacidium-like fungus. (a) Coryneum cinereum Dearn. This fungus reported in the last issue of Research Progress, from one location on the North Rim of the Grand Canyon, Grand Canyon National Park, Coconino County has extended its range eastward to Point Imperial and Cape Royal. Some trees were found in the vicinity of Point Imperial which were heavily attacked. On the same trees both Hypodermella medusa and Elytroderma deformans were detected. The infection of a single tree species in one locality with one needle-blight (Phacidium-like) and two needle-cast fungi (Elytroderma and Hypodermella) is of interest.

Histopathological studies revealed that Elytroderma deformans affects practically all needle tissues even getting into the phloem area of the vascular system. The Phacidium-like fungus has the same potential and usually does considerable damage to the vascular elements of the needle. The hyphae of the fungus invade the xylem in addition to the phloem. One curious effect of the Phacidium-like pathogen is the ability to cause hypertrophy in the transfusion tissues. This phenomenon was not noted with any of the other needle fungi, at least when invading needles of Pinus ponderosa. In cases where Phacidium was present phloem elements were invaded by hyphae, and cells therein showed hyphal elements in the intercellular regions. When Elytroderma is present as well as any second pathogen, effects on needle tissues appear to be similar to those caused when Elytroderma alone is present.

19. FUNGI OF ARIZONA. II.

Funds: Grant-in-aid funds from: The American Academy of Arts and Sciences, The Grand Canyon Natural History Association, and The Society of the Sigma Xi.
Personnel: Paul D. Keener.

Records of fungi on plant materials and other substrata from Arizona continue to be found as some of the old collections from various persons are studied and as field trips are taken during the year. In many instances current collections have been cured and inserted in herbarium cases to form what is hoped will be a permanent reference herbarium of Southwestern and other fungi.

Among the collections studied and deposited in the Phytopathological Herbarium this year were:

Alternaria sp. on the conk of a sp. of Ganoderma on Vitis sp. (var. Thompson Seedless)

Cercospora pteleae Wint. Leafspot on Ptelea angustifolia Benth.

Cercospora vexans C. Massalongo Leafspot on Fragaria sp.

Cenangium ferruginosum Fr. Canker on Pinus ponderosa Laws.

Coccomyces hiemalis Higgins Shot-hole on Cherry (unident. variety)

Coleosporium crowellii Cummins Rust on Pinus edulis Engelm.

Coleosporium jonesii (Pk.) Arth. Rust on Pinus edulis Engelm.

Coleosporium jonesii (Pk.) Arth. Rust on	Ribes inebrians Lindl.
Cronartium conigenuum (C. quercuum (Berk.) Miy.) Rust on	Quercus Emoryi Torr.
Darluca filum (Biv.) Cast. Fungus parasite on	Coleosporium crowellii Cummins.
Darluca filum (Biv.) Cast. Fungus parasite on	Coleosporium jonesii (Pk.) Arth.
Darluca filum (Biv.) Cast. Fungus parasite on	Cronartium quercuum (Berk.) Miy.
Elytroderma deformans (Weir)Darker Needle-cast on	Pinus cembroides Zucc.
Elytroderma deformans (Weir) Darker Needle-cast on	Pinus edulis Engelm.
Elytroderma deformans (Weir) Darker Needle-cast on	Pinus ponderosa Laws. (See further discussion in the text)
Fomes everhartii (Ell. & Gall.) von Schrank & Spauld. Wood rot on	Juglans major (Torr.) Heller
Fomes pini (Thore ex Fries) Karst Wood rot on	Pinus strobiformis?
Fomes robustus Karst Wood rot on	Cowania mexicana D. Don (Cliff-rose)
Fomes subroseus (Weir) Overh. (=F. cajanderi Karst.) Wood rot on	Abies concolor (Gordon & Glendinning) Lindl.
Ganoderma applanatum (Fomes applanatus (Pers.) Gill) Wood rot on	Populus tremuloides Michx.
Ganoderma sp. Wood rot on	Vitis, var. Thompson Seedless
Ganoderma sp. Wood rot on	Quercus sp.
Lenzites saepiaria (Wulf. ex Fr.) Fr. Wood rot on	Populus tremuloides Michx.
Macrophoma parca (Berk. & Br.) Berl. & Vogl. Needle-blight on associated on same needles with needle-case fungus, Hypodermella abietis-concoloris (Mayr) Dearn.	Abies concolor (Gordon & Glendinning) Lindl.
Nectria sp. Canker on	Acer glabrum Torr.
Mycenastrum corium Desv. Mycorrhizal associant under under	Quercus sp.
Phyllactinia guttata (Fr.) Lév. Powdery Mildew on	Alnus oblongifolia Torr.
Phyllactinia guttata (Fr.) Lév. Powdery Mildew on	Cornus stolonifera Michx.
Phyllactinia guttata (Fr.) Lév. Powdery Mildew on	Jamesia americana Torr. & Gray

Phyllactinia guttata (Fr.) Lév. Powdery Mildew on Robinia neomexicana Gray

Phyllactinia guttata (Fr.) Lév. Powdery Mildew on Amelanchier oreophila A. Nels.

Ramularia taraxaci Karst. Leafspot on Taraxacum officinale Weber.

Taphrina caerulescens (Desm.) Tulasne Leaf Blister on Quercus gambelii Nutt.

Taphrina bartholomaei Mix. Leaf Blister on Acer glabrum Torr.
on same leaves as a leafspotting fungus Phyllosticta sp.

Uromyces dactylidis Otth. Mitth. Rust on Alopecurus geniculatus L.*

Valsa ceratophora Tul. Canker on Alnus oblongifolia Torr.

Valsa sordida Nits. Canker and die-back on Populus tremuloides Michx.

*According to Dr. G. B. Cummins, Purdue University, Lafayette, Indiana this is a new host record for this rust.

Department of
POULTRY SCIENCE

1. ESTABLISHING A HEAT RESISTANT STRAIN OF WHITE LEGHORNS.

Project Number: 363. Funds: Hatch and State. Personnel: H. B. Hinds, A. A. Kurnick, B. L. Reid.

Line	Winter Prod. %	Summer Prod. %	Total Prod. %	Feed Lbs/ doz.	Body Wt. gms.
55	51.08	28.92	44.06	4.56	1529
553	54.71	25.25	45.74	4.63	1768
551	49.88	35.19	45.16	4.55	2012
552	64.92	54.77	61.74	3.74	1973

The rate of lay during the summer period decreased in all lots. This was most noticeable in lines 55 and 553, the strains of lighter bodied birds. Total production also declined during the summer.

Body weights were slightly below those of the previous year in all lots except 553, a heavy bodied bird. This strain also had the lowest feed conversion and the highest rate of summer production.

Supplementation of diets with either terramycin or oleandomycin did not have a beneficial effect on either summer or total production. It is apparent that the degree of inbreeding has interfered with the progress of selection.

2. EFFECTS OF TEMPERATURE ON PERFORMANCE OF LAYING CHICKENS AT VARIOUS AGES.

Project Number: 513 (W-50). Funds: Hatch and State. Personnel: B. L. Reid, H. B. Hinds and A. A. Kurnick.

A total of five experiments have been conducted, employing diets of 17% protein and productive energy levels of 965, 865, and 765 Calories/lb.

The first two experiments in this series were reported previously; the subsequent three were terminated during the past year. Birds were hatched in April, June, January, March and May. January hatched pullets attained sexual maturity at 128 days of age followed by the March (159 days), April(168 days), May (182 days), and June (194 days) hatches. Lower total production rates were obtained with the January hatched pullets than the other hatches.

Energy intake decreased 15-26% during the summer months as compared to the winter periods of these studies. The low energy diet (765 Calories/lb.) was beneficial in maintaining a higher intake of protein (above 18 grams per bird per day), vitamins and minerals during the summer months but proved to stimulate higher summer production by 3-5% in only two experiments.

Egg shell quality, measured by percent shell, or shell index, was substantially higher in birds fed the low energy diet during the summer months. This may be explained by the higher feed intake and, consequently, higher calcium intake obtained on this diet.

3. THE DIETARY EFFECTS ON EGG YOLK PIGMENTATION.

Project Number: 82. Funds: Grant-in-Aid Monsanto Chemical Company. Personnel: Y. V. Anjaneylu, A. A. Kurnick and B. L. Reid.

Dehydrated alfalfa meal at levels of 0 to 6.25% were fed to laying hens in the presence and absence of ethoxyquin. An 18% increase in egg yolk pigmentation was obtained with the feeding of the antioxidant. Feed analyses for beta-carotene and xanthophylls were made upon the completion of each of the three-week experiments. Carotene was found to be more readily oxidized than xanthophyll under the conditions of storage employed. The presence of ethoxyquin in the feed essentially prevented any destruction of either carotene or xanthophylls over the three-week storage period involved.

4. FLUORINE DEFICIENCY IN ANIMALS.

Project Number: A 2274. Funds: U. S. Public Health Service. Personnel: A. A. Kurnick, E. B. Kurtz, A. R. Kemmerer, B. L. Reid.

Sorghum and soybeans have been grown under hydroponic culture conditions thereby allowing a reduction of the fluorine content from 3.54 in the original sorghum seeds to 0.018 parts per million. The soybean seed originally planted contained 3.72 parts per million and was reduced to 0.018 parts per million by growing the plants under the low fluorine conditions. The nutrient solutions employed for the culture of these plants were made up from fluorine-free salts prepared by repeated recrystallization techniques. The second phase of the experimental work on this project will involve the feeding of such low fluorine dietary ingredients to rats in order to evaluate the requirements of the rat for fluorine.

5. THE ROLE OF PHOSPHORUS IN LAYING HEN NUTRITION.

Project Number: 76. Funds: Grant-in-Aid International Minerals & Chemical Corp. Personnel: T. A. Crowley, A. A. Kurnick and B. L. Reid.

Two types of experimental diets were employed in these studies. The supplemental phosphorus levels used were 0.19% up to 0.735% total phosphorus in the diet. The feeding of these diets to birds housed on litter indicated that the dietary phosphorus requirement for the laying hens is no more than 0.28%. When the same diets were fed to birds housed in individual laying cages the dietary phosphorus requirement for egg production appeared to be at least 0.415%. Serum calcium and phosphorus levels were determined and found to be lower in the birds housed in cages than in the birds on similar diets housed on litter. Average egg weight was apparently not affected by the dietary levels of phosphorus employed in these studies.

6. THE UTILIZATION OF ARIZONA CROPS IN CHICK DIETS.

Project Number: 364. Funds: Hatch and State. Personnel: B. L. Reid, A. A. Kurnick and A. J. Deutschman, Jr.

Storage of eggs from hens fed 20% cottonseed meal under atmospheres of air, oxygen, carbon dioxide or nitrogen failed to either accelerate or decrease the incidence of pink whites. Eggs showing the pink-white defect yielded pH values on the yolks and whites which were 8.26 and 8.23 respectively. Normal eggs from soybean meal fed birds or eggs from hens fed cottonseed meal which failed to discolor, showed pH values which were almost identical. These values were 6.5-6.85 for the yolk and 8.09-8.23 for the whites. These data indicate that a pH change within the yolk is necessary in order to develop the pink-white discoloration. The treatment of Sterculia foetidia oil, which contains a fatty acid similar to the malvalic acid found in cottonseed meal, with either HCl or SO_2 gas destroyed the Halphin reactivity of the oil and eliminated the development of pink whites in stored eggs from hens fed these materials.

Cottonseed meal when treated with SO_2 gas prior to feeding failed to cause either pink-white or gossypol discoloration in stored eggs. Eggs from these hens also failed to discolor when exposed to an ammonia atmosphere in the accelerated test for gossypol. The treatment of cottonseed meal with SO_2 appeared to destroy both the pink-white discoloring capacity and the olive yolk effect of cottonseed meal feeding.

7. THE ROLE OF EGG CARTON LABELING IN THE RETAIL MARKETING OF EGGS.

Project Number: 469. Funds: Hatch and State. Personnel: Tom Clark, A. A. Kurnick, R. E. Seltzer, F. D. Rollins, B. L. Reid.

Three cartons were employed in a standard open-type display case in three local supermarkets for a period of one week in each market. Each display consisted of the standard egg carton of a well-known local brand of eggs; the second type consisted of the same standard carton to which was affixed a colored panel only; and a third consisted of a standard carton plus the colored panel with the information printed on this label to the effect that "2 eggs supply 17.4% of the minimum daily protein requirements for adults." Egg cartons containing the printed protein information accounted for 53% of total sales from this display. Standard egg cartons sold at the rate of 26%, while the carton with the blank, colored panel amounted to 21% of the total sales.

Questionnaire results indicated that 3/4 of the consumers interviewed ranked nutrition first over cost and attractiveness in planning meals. Over 1/4 of the consumers rated freshness of eggs as the most desired characteristic, 2/5 of the consumers did not know any of the 4 U.S. grades of eggs, while 3% were familiar with all 4 grades. The term "local eggs" was thought by 4/5 of the consumers to mean that the eggs were laid in the Tucson area and over 4/5 of the consumers preferred to purchase Arizona-produced eggs. The average number dozen eggs purchased each week by consumers interviewed was 2-3 dozen.

8. THE GROWTH OF WHITE LEGHORN PULLETS FED HIGH LEVELS OF BENTONITE.

Project Number: 86. Funds: Grant-in-Aid: American Colloid Company.
Personnel: B. L. Reid, H. B. Hinds and A. A. Kurnick.

White Leghorn pullets hatched in March, 1960, were fed six different growing rations from 9 weeks of age to sexual maturity. The control diets employed in this study contained 18% protein and 970 Calories/lb.; while the pullet developer rations contained 13% protein and 566 Calories/lb. and 25% bentonite or 25% added cellulose in the form of wood pulp. In addition, a treatment was incorporated in which the birds were fed the high energy, high protein ration at the rate of 10 pounds per hundred birds per day in order to evaluate the effects of the pullet developer diet system and to compare this method to that of physical restriction of high energy type rations. The age at first egg, or time of sexual maturity, was 155 days for the high energy, full-fed control group. The physical limitation of the amount of feed available for consumption resulted in a delay of sexual maturity to 185 days with the feeding of 10 pounds of feed per hundred birds per day. When 25% bentonite was incorporated into the diet to produce a 566 Calorie ration at 13% protein, sexual maturity was 177 days, as compared to 181 days when 25% wood pulp was incorporated into the same diet.

Institute of
WATER UTILIZATION

1. INVESTIGATION OF SITES, METHODS, AQUIFER DETERIORATION CONTROL, AND EFFECTS OF ARTIFICIAL GROUND WATER RECHARGE OF ALLUVIAL BASINS TYPICAL OF THE ARID SOUTHWEST UNITED STATES.

Project Number: 505. Funds: G-8. Personnel: George E. Maddox, Sol. Resnick, and one half-time Research Assistant.

Preliminary planning has been completed for a recharge operation to be carried out in cooperation with the U. S. Bureau of Indian Affairs. When it becomes operational, the project will recharge up to 4,000 acre-feet of flood water yearly to the ground water table to make up for pumping overdraft in an irrigated farm planned for the Papago Indians. Pre-recharge water treatment facilities will include desilting and chemical treatment to control bacteria in the sediment laden flood water.

Experiments are under way to determine the ability of grasses to remove sediment from surface water to be used for recharge. At the Safford Experimental Farm of The University of Arizona, seven 900' x 28' plots of grasses (lahonton alfalfa, vine mesquite, common bermuda, coastal bermuda, blue panicum, panicum coloratum, and goars fescue) have been planted. In midsummer, when these grasses have matured, muddy water from the Gila River will be run over the grass and a measure of the turbidity decrease made at various points as the water flows down the border. If successful, the grass plot method could provide a cheap efficient way to remove sediment from surface water, and make it ready for recharge, besides giving an additional crop to the person recharging.

Research has begun on studying the effectiveness of pea-gravel filters in removing sediment from recharge water. Past research in Arkansas and California and practical application of pea-gravel filters in recharge operations in Peoria, Illinois,has lead to conflicting views on the effectiveness of pea-gravel filters in removal of sediment from water. Since the amount of quantitative research done with pea-gravel filters has been very small in comparison with their potential as a method of removing sediment from water, we have begun an investigation of the causes and effectiveness of pea-gravel filtration, and the applicability of pea-gravel filters as a cheap, efficient method of removing sediment from water.

The first phase of an investigation of the potential of artificial ground water recharge as a method of handling excess irrigation tail-water was completed in June 1960, with the recharge of a total of three and one-half acre-feet of tail-water which had low turbidity and was chemically treated to control bacteria. The second phase of the investigation, just starting, will be to recharge tail-water which has been treated to control bacteria, but which has all of its suspended sediment content. This "muddy" water will be recharged into a "shallow" dewatered aquifer and will be allowed to flow through this aquifer and down nearby irrigation wells which are perforated in the recharged aquifer. Tests will be made of water in irrigation wells recharged in this manner in order to determine any change in the amounts of suspended sediment and for the presence of bacteria in the wells.

Preliminary plans have been completed for an artificial ground water recharge project in cooperation with the U. S. Soil Conservation Service near Dos Cabezas, Arizona. Here, excess flood water from the Dos Cabezas Watershed will be recharged so that it may be recovered by farmers down the hydraulic gradient from the point of recharge. At the present time this flood water is being lost by evapotranspiration on the Willcox Playa.

2. REDUCTION OF EVAPORATION LOSSES BY USING MONOMOLECULAR FILMS.

Project Number: 507. Funds: State. Personnel: Sol Resnick, Project Leader, David Kincaid, Howard Goldstein.

Study of Evaporation Reduction from Class A Evaporation Pans: At present four evaporation pans are being used - three treated and one untreated. Data kept on these pans show an average saving of about 64% of the water normally lost through evaporation. Evaporation suppressants currently in use are Cetostearyl 5844, Aquasave 1-SD, and Hexadecanol 5744.

Study of the Chemical Properties of the Common Long-Chain Alcohols being used for Evaporation Reduction: Infra-red spectrums of 4 evaporation suppressants (Tensia Stearylaz, Aristo 5744, Aristo CE-50, Applied Science Laboratory Cetyl Alcohol 10t230-70) have been obtained. The spectrums of the commercial samples matche that of pure hexadecanol quite closely. There is some indication of unsaturation and the presence of a small amount of acid. These samples will be analyzed again after having been used on a water surface for a period of time to detect what changes, if any, have occurred in their chemical composition.

Differential Evaporation Apparatus: A differential evaporation apparatus has been constructed which is able to measure the difference in evaporation rate between two water surfaces to an accuracy of 0.001 grams per minute. Modifications of the apparatus to give a completely airtight system are now in progress.

Duplicate Tanks: Two similar tanks 53 x 78 x 9 ft. deep have been constructed and are presently being lined with plastic.

3. SELECTION AND TESTING OF MATERIALS FOR SURFACING WATERSHED AREAS.

Project Number: 508. Funds: State. Personnel: Sol Resnick, Ervin Schmutz, Richard Shaw, David Kincaid.

Recording rainfall and runoff records were collected for the Page Ranch asphalt-paved runoff area which has been in operation for ten years.

Literature survey and other background work was continued. Discussions had with ARS, Southwest Water Conservation Laboratory researchers, who are screening the many chemicals proposed for paving. Excellent low-cost chemicals for paving are available, but there is now need for soil stabilizers to prevent excessive erosion resulting when above chemicals are used. Laboratory facilities were completed during the year.

Department of
WATERSHED MANAGEMENT

1. THE RANGE RESOURCES OF ARIZONA.

Project Number: 232. Funds: Hatch. Personnel: R. R. Humphrey.

The work previously initiated in Pima, Pinal, and Santa Cruz Counties has been completed and published as Experiment Station Bulletin 302. Five vegetation types: Pine-fir forest, juniper-oak woodland, chaparral, desert grassland, and southern desert shrub are described on a basis of four condition classes - excellent, good, fair, and poor. In most instances these are further subdivided and discussed on a basis of site classes. The bulletin includes (a) an analysis of woody plant invasion as a cause of deterioration in the desert grassland, (b) a section on management of each vegetation type to obtain maximum sustained yield of forage, (c) a section on control of woody plants, and (d) a discussion of the forage and management characteristics of the plants mentioned in the text. The bulletin is profusely illustrated with half-tone cuts, line drawings, and a five-color vegetation map.

2. CONTROL OF NOXIOUS SHRUBS ON SOUTHWESTERN RANGES.

Project Number: 285. Funds: Hatch. Personnel: E. M. Schmutz, R. F. Wagle, G. L. Anklam.

CHOLLA AND PRICKLY PEAR CACTUS

Jumping cholla plants were chopped at monthly intervals to simulate chaining. Initial sprouts as high as 6,000 to 7,000 per acre occurred during the moist warm periods from February-April and July-August. Lowest initial sprouting, 200 to 300 sprouts per acre, occurred during the cold and dry periods October-December and May-June, respectively. After four years, continuing death loss is eliminating seasonal differences with surviving sprouts varying from 50 to 190 per acre. Sprouting does not show a consistent correlation with humidity, temperature or soil moisture. It is most influenced by seasonal rainfall.

BURROWEED

Reactivation of this study is pending receipt of additional funds.

OAK CHAPARRAL

A three-year study of airplane and hand-spray applications of herbicides on fire sprouts of turbinella oak showed that repeated light applications (1 - 1 2/3# per acre) were more effective in controlling sprouts than single heavy applications (3-5# per acre) and that 2,4,5-T propionic compounds were more effective than regular 2,4,5-T esters. However, isooctyl, pentyl and tetrahydrafurfuryl compounds also show promise.

Highest total kill from the airplane tests, 44 per cent, resulted from three consecutive-year light applications of silvex. Lower total kills of 30, 7, 7 and

20 per cent resulted from two-consecutive-year light, two-alternate-year light, single-year light, and single-year heavy applications of silvex, respectively. In general, topkill was two to three times greater than total kill; grass production increased markedly as shrubs decreased; and high-volume hand spray tests resulted in higher kill than the low-volume airplane applications.

Fenuron was effective at 16 and 32# commercial rates, resulting in 43 and 95 per cent total kill, respectively; but monuron, urab and silvex granules gave poor results.

CREOSOTEBUSH, TARBUSH AND WHITETHORN

Hand-spray tests on creosotebush, tarbush and whitethorn with 2,4-D and 2,4,5-T herbicides continued to give high kills at low 1 to 2 pound rates when applied approximately 30 days after the summer rains begin. With ground-rig applications, four to eight-pound rates were necessary to give effective, 50 to 80 per cent, kills. However, better timing of seasonal and time-of-day applications, plus carrier factors, promise more effective results. Marked increases in grass growth were observed following brush control.

Granular herbicides were generally most effective when applied at the beginning of the summer rainy season. Fenuron and monuron produced high, 40-100 per cent kills at 8# commercial rates; urab produced intermediate results; and PBA and silvex granules generally produced low kills.

3. SHRUB INVASION-FORAGE PRODUCTION INTERRELATIONS ON ARIZONA RANGELANDS.

Project Number: 292. Funds: Hatch. Personnel: E. M. Schmutz, D. G. Wilson, R. F. Wagle, D. W. Whitham.

Studies were made on several shrubby ranges to measure the effect of various shrub control treatments and ecological factors on grass-shrub relationships and forage production.

On a shrubby desert grassland range near Tucson, removal of all shrubs vs. burroweed and broomweed only did not produce significantly different results during the five-year period from 1954 to 1959. Both treatments increased grass density and grass production was increased from an average of about 400# to 600# per acre.

On burned and reseeded oak-chaparral lands near Dewey, Arizona, during the 3-year period 1957 to 1959, various airplane treatments of shrub sprouts with 2,4,5-T herbicides reduced shrub growth and increased grass production an average of 655 pounds per acre from approximately 345# per acre on unsprayed plots to over 1,000# average for all spray treatments. The greatest increase of grass production, 1030# per acre, resulted from three-consecutive-year light (1 2/3 pounds per acre) applications. The two-alternate-year light, single-year light, and single-year heavy (5 pounds per acre) applications produced smaller increases of 867, 448 and 278# per acre respectively. Assuming 50 per cent as useable forage, the increased growth would repay the respective costs of light applications in 2 to 3 years and the heavy applications in 7 to 9 years.

On a mixed-gramma grassland range on the Santa Rita Experimental Range, physical and chemical analyses of a Whitehouse sandy loam soil showed that in

mesquite-invaded areas this soil was more coarse textured while in the uninvaded areas this soil was significantly higher both in clay and organic matter, and had a greater grass density.

4. POISONOUS PLANTS OF ARIZONA.

Project Number: 328. Funds: State Research. Personnel: D. G. Wilson.

Additional information on the distribution and occurrence of poisonous plant species was compiled. Poor moisture conditions prevailed over most of the state, making it difficult to do any extensive collecting.

5. CHANGES IN THE DESERT GRASSLAND - AN ANALYSIS OF CAUSES.

Project Number: 365. Funds: Regional Research (W-25). Personnel: R. R. Humphrey (Supervising), Patrick D. Dalton, Donald E. Johnson, Joel E. Verner.

Tobosa Grass.

Observations on habitat characteristics were recorded on three tobosa grass communities in three geographic areas that were distinct climatically, edaphically and floristically. Soil-moisture and precipitation data were obtained at two locations on one of these sites from June 10, 1959 to September 2, 1960. The soil moisture analyses were made at four depths -- 0-6", 6-12", 12-18", and 18-24".

Creosotebush.

Data have been collected on nine lines of creosotebush investigation: (1) Distribution in Arizona, (2) composition of plant communities containing creosotebush, (3) anatomy and morphology, (4) factors affecting seed germination, (5) root ecology, (6) phenology, (7) leaf-moisture content, (8) growth inhibitors produced by Creosotebush, (9) effects of fire. Results of the study are currently being prepared for publication.

6. SEED INCREASE AND PRELIMINARY EVALUATION OF PLANT INTRODUCTIONS THAT MAY BE SUITED TO THE SOUTHWEST.

Project Number: 368. Funds: Regional Research (W-6). Personnel: L. P. Hamilton and D. G. Wilson.

394 lines, principally grasses, were grown on the Center during 1960. One hundred and sixty-six for seed increase. The genera represented, and promising lines, are listed below. They include a number of lines of Eragrostis and Pennisetum which appear to merit range testing.

Promising Lines

Three lines of buffel grass, P.I. 240,169 and P.I. 240,171 from Morocco and P.I. 243,198 from So. Rhodesia are bushy range types having good seed production.

Eight lines of Eragrostis produce leafy range types with good seed habits. They appear promising for further range tests.

16209	Eragrostis robusta	209,385	So. Africa
16252	Eragrostis robusta	234,218	So. Africa
16187	Eragrostis sp.	208,232	So. Africa
16153	Eragrostis robusta	207,951	So. Africa
16161	Eragrostis sp.	208,091	So. Africa
16174	Eragrostis sp.	208,161	So. Africa
16175	Eragrostis curvula (Conferta)	208,163	So. Africa
16170	Eragrostis margaritacea	208,131	So. Africa

W-6 LINES UNDER TEST OR INCREASE 1960-61 GROWING SEASON

AELEUROPIS	9	ERAGROSTIS	135	PANICUM	1
AGROPYRON	7	ENNEAPOGON	1	PENNISETUM	10
ASTRAGALUS	3	ELEUSINE	1	PHALARIS	106
BOUTELOUS	1	FESTUCA	6	PIPTANTHUS	1
BRACHYPODIUM	9	HYPARRHENIA	1	RHAMNUS	1
BROMUS	4	LAGURUS	1	SELAGO	1
CYMBAPOGON	1	MEDICAGO	1	SETARIA	2
CYNODON	8	MELILOTUS	1	STIPA	3
DACTYLIS	33	MIMOSA	1	SORGHUM	2
BRIOCEPHALOS	1	ORYZOPSIS	40	SUTHERLANDIA	1
				TRIFOLIUM	2

Total: 394

7. ECOLOGICAL EFFECTS OF FERTILIZERS ON DRYLAND RANGES.

Project Number: 424. Funds: State Research. Personnel: D. G. Wilson.

A ten-treatment study was superimposed on the Hatch 292 forage production plots on the Page-Trowbridge Ranch. The plots were reweeded to insure comparable shrub composition to the original purpose.

The following treatments were applied on July 14 and 15, 1960 - three levels of nitrogen (25,50 and 74# N/acre); three levels of phosphorcus (31, 62 and 93# P_2O_5/acre); three levels of nitrogen and phosphorous (25-31,50-62 and 75-93# N and P_2O_5); and unfertilized.

Approximately one-half inch of rain was received on July 24 and was sufficient to dissolve the fertilizer pellets. However, no response to fertilizer treatment was noted as subsequent rainfall was very erratic and total precipitation for the growing season was 2.7 inches. Winter precipitation for 1960-61 has likewise been very deficient.

8. RESEEDING OF ARIZONA RANGES.

Project Number: 470. Funds: State Research. Personnel: L. P. Hamilton, James Burrell, D. G. Wilson.

One hundred and four germination counts were made at the Plant Materials Center to establish germination patterns of thirty-five range grasses. An additional 11,000 seedling counts were made to follow the dormancy pattern of a 1960 field collection of Lehmann lovegrass. Additional information was obtained on the use of fungicides, pre-chilling, effect of temperature, and effect of age and condition of the seed germination. Results of 54 samples in the Plant Materials Center files were catalogued.

Under a separate branch of the project, point distance and point-quadrat data were obtained over the state from plantings two to ten years old, principally in Cochise, Yavapai, and Mohave Counties. Species and strain comparisons were made in plantings at Holbrook, Linden and Hereford. The effect of reduction of annual competition and methods of covering Boer lovegrass seeds were evaluated at Rancho Sacatal.

9. GROWTH VARIATION IN QUERCUS TURBINELLA, GREENE, AND ITS RELATION TO ENVIRONMENT.

Project Number: 486. Funds: Regional Research (W-63). Personnel: Robert F. Wagle and David Whitham.

Soil collections have been made and soil fertility assays have been continued over this past year.

One series of plots in old growth (unburned in known history) turbinella oak has been treated with a series of macronutrients.

In last year's report, the preliminary results were given for Quercus turbinella plants which were treated in the winter with five different rates of 25% fenuron. The effect of this chemical on oak has now been analyzed nearly two years after application.

An ecological and economic analysis was also made of the forage increase and shrub decrease obtained after single and successive treatments on a number of plots sprayed by airplane, with Silvex and 2,4,5-T.

10. THE MANAGEMENT OF SECOND-GROWTH PONDEROSA PINE.

Project Number: 509. Funds: State Research. Personnel: P. N. Knorr, R. F. Wagle, A. L. McComb, P. B. Rowe.

The effect of prescribed burning on fire control and on stand structure and composition.

For more than a decade prescribed burning of ponderosa pine lands has been practiced to the extent that fuel, weather conditions and personnel permitted it on the Fort Apache Indian Reservation. The objective of this study is to determine if wild-fire frequency has changed as a result of the prescribed burning treatment as well as determining if there are differences in the size of the wildfires that do occur. Other effects of prescribed burning that affect feasibility of fire as a forest management tool can and will be studied insofar as the data are available.

The individual fire reports for the last few years have been placed on IBM coding sheets preparatory to punching for machine analysis. Most of the recording has been completed except for designating whether or not the area of each individual fire has been previously burned. This task will require much more time and, in many cases, considerable field checking. It is hoped that by next year the effect of prescribed burning in second growth ponderosa pine stands will help in deciding value of these practices on the Fort Apache Indian Reservation.

Growth and yield of second growth ponderosa pine in relation to stand density and thinning.

The new pulp and paper plant near Snowflake, Arizona will be supplied largely from thinnings from ponderosa pine. The objective of this study is to obtain a guide as to the proper density to thin second growth ponderosa pine stands on specific sites for maximum commercial volume growth.

Aerial photographs were employed to locate possible sites for thinning studies. Field reconnaissance resulted in plot locations for other experiments, but further field examinations are necessary to locate stands suitable for thinning studies.

To develop new methods of thinning dense, stagnating second growth stands.

Many of the forestry problems of Arizona relate to the dense stagnated ponderosa pine stands prevalent in many parts of the state. There is a need for pre-commercial thinning in these stands. The use of fertilizers, other growth-promoting substances and herbicides to reduce stand density by stimulating an expression of dominance in some trees and bringing about suppression and mortality in other trees, is the objective of this research.

One hundred plots have been established near McNary, Arizona and treated during the past year. The fertilizer, growth-promoting substance and herbicide treatments are as follows: NPK(S); NPK(S) plus five minor elements; PK(S); NK(S); NP(S); no litter; double litter; selective full treatment-NPK(S) plus five minor elements; selective fenuron; nonselective fenuron; selective gibberellic acid; selective gibberellic acid,plus full fertilizer-NPK(S), plus minor elements.

All trees in each plot have been identified and measured for diameter and height. This summer growth bands will be placed on designated trees in each plot for permanent records of changes in growth.

Effects of thinning and prescribed burning on the water cycle.

Water is the most vital resource of Arizona's wildland watersheds. The state's local water supply is inadequate to meet present or future needs. Results

of past and current research indicate that the supply of local water can be appreciably increased through the application of suitable watershed management practices. To be economically feasible such practices must be based on sound knowledge of the relations between the hydrologic processes and the physiographic variables of the land, and of the conditions of rainfall, soil, and vegetation capable of yielding desired results. Three studies are being carried on in hope of contributing to the basic information needed in achieving this kind of watershed management. The following progress was made during the year:

a) Field work was completed and analysis of results started in a study to develop methods of evaluating effects of vegetation manipulation on evaporation and on transpiration from ponderosa pine stands.

b) The experimental design was established and tests started to evaluate effects of different levels of soil moisture and solar radiation on evaporation and transpiration from potted Aleppo pine seedlings.

c) A work plan is in preparation for a study to compare effects of natural grass, brush and juniper vegetation types on the structure, permeability, and infiltration capacities of soil.

11. RESEEDING SEMI-ARID RANGELANDS IN ARIZONA -- PELLETED SEED VS. UNPELLETED SEED.

Project Number: 2RC. Funds: Bureau of Land Management. Personnel: O. D. Knipe; L. D. Hamilton; R. R. Humphrey, and E. M. Schmutz; Dr. Lytle S. Adams, Consultant.

This study is designed to solve some of the basic problems necessary to the success of range reseeding, and to evaluate the effectiveness of reseeding with seeds of grasses encased in earthen pellets and disseminated by airplane. Evaluation will be effected through extensive soil moisture studies, supplemental rain studies, and various seedbed preparation treatments.

Two sites on U.S.D.I., B.L.M. lands have been selected, fenced, and plots located for seeding in June, 1961. The necessary equipment (climatological instruments, tillage and seeding equipment, air seeding service, etc.) have been purchased or arranged for.

Germination tests (pelleted vs. unpelleted seed) are in progress at the present time; these will be completed by April 1.

Greenhouse studies, using soil from the experimental areas, designed to determine the optimum depth of planting and seedbed compaction for black gramma and lehmann and boer lovegrass have been completed. These studies indicate that seed coverage of 1/8 to 1/2 inches and compaction of approximately three pounds per square inch are desirable for effecting seedling emergence and establishment.

12. TRANSPIRATION STUDY.

Project Number: 2RC. Funds: Pack Foundation. Personnel: David R. Kincaid, R. F. Wagle (Advisor).

Transpiration rates of arid-land plants have been measured as they relate to air temperature, light intensity and the vapor pressure deficit between leaf and air. These measurements were made at constant soil moisture tension. Although the transpiration rate generally follows the vapor pressure deficit, fluctuations caused by varying light intensities are quite apparent.

13. ANNUAL RING STUDIES IN DESERT SHRUBS.

Project Number: G-5568. Funds: National Science Foundation. Personnel: R. R. Humphrey, Principal Investigator; C. W. Ferguson, Research Associate; G. C. Kenny and K. E. Day, Assistants; R.A. Wright, Assistant in Research.

The project continued an exploratory investigation of growth rings of woody plant species in and adjoining the desert grassland of southwestern United States and northern Mexico. The study of nearly 200 species has indicated that a small percentage of these do have a definite annual growth ring. The knowledge of growth ring-environment relationships of species of positive value is being expanded in terms of length of chronology, number of species, and geographic area.

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December 31, 1960

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Anne-Marie Rascop, Assistant in Research

Entomology Department

Laurence A. Carruth, Head of Department
Frank E. Todd, Entomologist
Floyd G. Werner, Entomologist
George D. Butler, Jr., Associate Entomologist
Paul D. Gerhardt, Associate Entomologist (Mesa)
William L. Nutting, Associate Entomologist
Donald M. Tuttle, Associate Entomologist (Yuma)
George P. Wene, Associate Entomologist (Mesa)
James M. Witt, Associate Entomologist
Lois B. Koenig, Assistant in Research
George L. Arvizo, Assistant in Entomology (Yuma)
Martha L. Noller, Assistant in Entomology
Don L. Turley, Assistant in Entomology (Mesa)

School of Home Economics

Ruth C. Hall, Director
Victor A. Christopherson, Family Relationships Specialist
Ethel M. Thompson, Nutritionist
Alida S. Hotchkiss, Associate Home Economist
Faye C. Jones, Associate Housing Specialist
Mary Ann Kight, Research Associate

Horticulture Department

Leland Burkhart, Head of Department
William P. Bemis, Horticulturist
Robert E. Foster, Horticulturist (Mesa)
Robert H. Hilgeman, Horticulturist (Tempe)
Weymouth D. Pew, Horticulturist (Mesa)
John R. Kuykendall, Associate Horticulturist
David R. Rodney, Associate Horticulturist (Yuma)
Paul M. Bessey, Assistant Horticulturist (Mesa)
Steve Fazio, Assistant Horticulturist
Joseph S. Folkner, Assistant Horticulturist
Thomas A. Hales, Research Associate (Yuma)
George G. Sharples, Research Associate (Mesa)
Henry C. Williamson, Jr., Research Associate (Yuma)
Charles R. Everling, Assistant in Research (Tempe)
Edward L. Murdock, Assistant in Horticulture (Mesa)
James H. Park, Assistant in Horticulture (Mesa)

Plant Breeding Department

Elias H. Pressley, Head of Department
Walker E. Bryan, Plant Breeder
Warner D. Fisher, Plant Breeder (Tempe)
Lee S. Stith, Plant Breeder
David C. Allison, Assistant Plant Breeder (Tempe)
Hiroshi Muramoto, Assistant Plant Breeder
Robert L. Voigt, Assistant Plant Breeder
Clifton C. Manderscheid, Assistant in Research (Tempe)
Jean L. Dykeman, Assistant in Plant Breeding

Plant Pathology Department

George A. Gries, Head of Department
Paul D. Keener, Plant Pathologist
Rubert B. Streets, Plant Pathologist
Ross M. Allen, Associate Plant Pathologist (Yuma)
Alice M. Boyle, Associate Plant Pathologist
Robert B. Marlatt, Associate Plant Pathologist (Mesa)
Merritt R. Nelson, Assistant Plant Pathologist (Yuma)
Herbert H. McDonald, Assistant in Research (Yuma)
Robert T. McKittrick, Assistant in Research (Mesa)

Poultry Science Department

Allen A. Kurnick, Head of Department
Burt W. Heywang, Poultry Scientist
Bobby L. Reid, Poultry Scientist
Hubert B. Hinds, Associate Poultry Scientist

Watershed Management Department

Andrew L. McComb, Head of Department
Robert R. Humphrey, Range Management Specialist
Philip N. Knorr, Associate Forester
Percy B. Rowe, Associate Watershed Management Specialist
David G. Wilson, Associate Range Management Specialist
Robert F. Wagle, Assistant Watershed Management Specialist
C. Wesley Ferguson, Research Associate
Ervin M. Schmutz, Research Associate
Oren D. Knipe, Assistant in Research
Robert A. Wright, Assistant in Research

Plant Materials Center:
Louis P. Hamilton, Manager
Ellsworth G. Hendricks, Assistant Manager
James M. Burrell, Assistant
Odas T. Mahan, Assistant

Water Utilization (Institute of)

Sol D. Resnick, Head of Department
George E. Maddox, Research Associate

BRANCH STATIONS

Charles W. Fitzgibbon, Superintendent, Cotton Research Farm, Tempe ✓
Jesse L. Redman, Foreman, Cotton Research Farm, Tempe
Harold E. Reyher, Foreman, Marana Farm, Marana ✓
Weymouth D. Pew, Superintendent, Mesa Farm, Mesa ✓
David C. Aepli, Farm Specialist, Mesa Farm, Mesa
Laurel D. Leavitt, Foreman, Mesa Farm, Mesa
Larue C. Chapman, Superintendent, Safford Farm, Safford ✓
James N. Davis, Foreman, Safford Farm, Safford
Robert H. Hilgeman, Superintendent, Salt River Valley Citrus Farm, Tempe ✓
Ernest H. Hussmann, Superintendent, University Farms, Tucson ✓
William N. Hall, Foreman, Tucson Farm, Tucson ✓
Frank Pritchard, Superintendent, Yuma Farm, Yuma ✓
William C. Etier, Foreman, Yuma Valley Farm, Yuma ✓
Howard P. Conley, Foreman, Yuma Mesa Farm, Yuma ✓
F. W. Richardson, Superintendent, Poultry Farm, Tucson ✓
Erle F. Adams, Foreman, Poultry Farm, Tucson